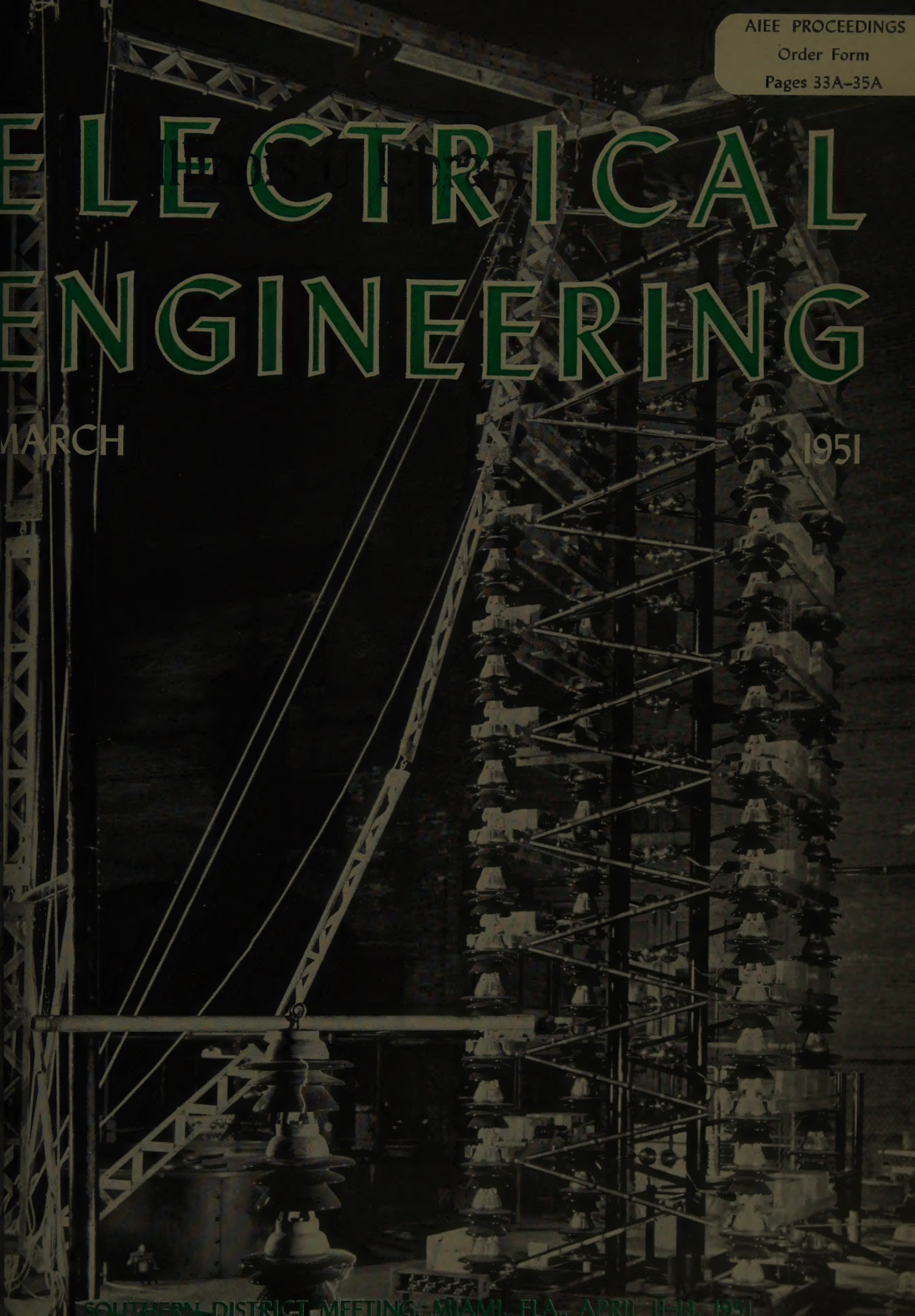
AIEE PROCEEDINGS
Order Form
Pages 33A–35A

ELECTRICAL ENGINEERING

MARCH 1951



SOUTHERN DISTRICT MEETING, MIAMI, FLA., APRIL 11-13, 1951

5 kv outdoor metal-clad switchgear with DZ 60 B oil circuit breakers rated 150 mva installed at an east coast utility.

WHEN INDOOR space becomes limited — go OUTDOORS where there's lots of room for future expansion. You save valuable indoor space for other equipment, eliminate expensive building additions or changes.

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Allis-Chalmers Switchgear is All-Weather Protected: (1) welded-in steel floor plates form a tight bottom seal; (2) overhanging eaves keep out driving rain and sleet; (3) weather proof doors, 3-point latched, close firmly; (4) steel surfaces are phosphate treated prior to receiving multiple coats of weather-tested paint that makes them corrosion and weather resistant; (5) structure rests on 6″ base channels; (6) ice and sleet guards protect locks; (7) copper mesh filters furnish protected ventilation.

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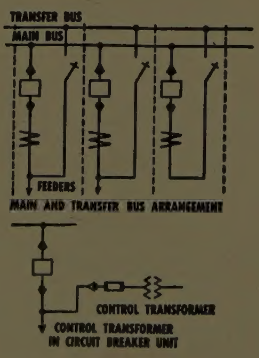
VARIED CIRCUIT ARRANGEMENTS

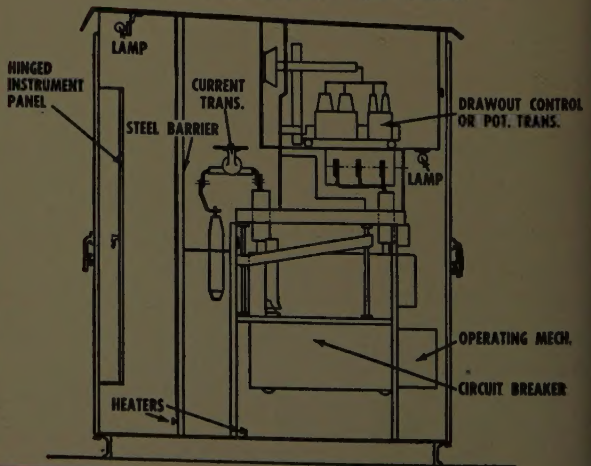
Unique compartment design permits many circuit arrangements in a standard breaker unit. Two typical arrangements are shown:

1. Double bus arrangement with transfer bus and disconnect switch above the main bus compartment. All equipment is easy to get to without extra provisions.

2. Control power transformer arrangement that eliminates the need for an extra auxiliary compartment. Generally used for secondary control battery charging and to supply power for space heaters and lighting applications.


TRANSFER BUS
MAIN BUS
FEEDERS
MAIN AND TRANSFER BUS ARRANGEMENT
CONTROL TRANSFORMER
CONTROL TRANSFORMER IN CIRCUIT BREAKER UNIT

CONSTRUCTION DETAILS



ELECTRICAL ENGINEERING

Registered United States Patent Office

MARCH
1951

The Cover: Three million volts of lightning is the capacity of a new impulse generator recently installed in the high-voltage testing laboratory of Locke Incorporated, Baltimore, Md. The generator is used for routine checks on production as well as design tests on new insulators. The corner supporting columns are Locke's own switch insulators Number 7785 instead of the customary Herkolite cylinders.

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Statements and opinions given in articles appearing in *ELECTRICAL ENGINEERING* are expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on controversial matters.

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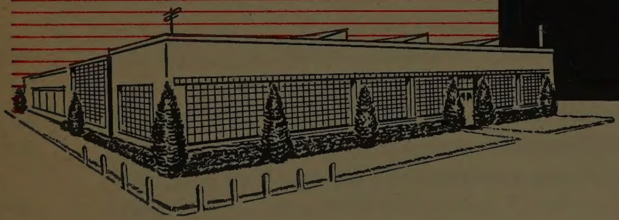
Welded
GERMANIUM DIODES

NEW MANUFACTURING FACILITIES INCREASE PRODUCTION 200%!

New G-E diode plant at Clyde, New York



In a nutshell, here's what General Electric offers electronic equipment manufacturers:

Plant Capacity to help meet total estimated industry and mobilization requirements of germanium diodes and associated products . . .

Proved Design backed by research that is steadily increasing the use of diodes in place of vacuum tubes in many circuits . . .

Lower Costs than any other diode manufacturer offers today . . .

Application Engineering Service that will put G-E diode engineers to work on your circuit problems at your request . . .

We would like to discuss your requirements. As a start, let us send you Bulletin X57-015 covering the specifications of our diodes. Write to the *General Electric Company, Section 4631, Electronics Park, Syracuse, New York.*

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General Purpose		Television	JAN	UHF	Quads	Transistors
1N48	1N63	1N64	1N69	1N72	1N73	SX-4A
1N51	1N75	1N65	1N70		1N74	Z-2
1N52						

You can put your confidence in—

GENERAL ELECTRIC

HIGHLIGHTS........

Members of the Institute who are Registered Professional Engineers. Attention has been called by the Chairman of the Committee on Registration of Engineers, Elgin B. Robertson, to the fact that there are a great many more registered professional engineers who are members of the Institute than is indicated in the 1950 Year Book. When Year Book cards are received, please be sure to fill in all information requested and return the cards. Do not fail to check the question, "Are you a registered professional engineer?"

Members and Money. Two material changes in the Constitution have been proposed (*pages 183–4*). Within a few days each AIEE member will receive a ballot covering these changes in membership requirements and dues provisions. President LeClair requests that members return the ballots promptly. *Please do not forget or neglect to mail your constitutional ballot!*

Edison, Hoover, and John Fritz Medals. At three general sessions during the 1951 Winter General Meeting, Otto B. Blackwell, Karl T. Compton, and Vannevar Bush were awarded the Edison, Hoover, and John Fritz medals respectively. The presentation and acceptance addresses of all the medalists are carried in full in this issue (*pages 185–201*).

Development of Engineering as a Profession. Will engineering ever become a profession in the eyes of the public? Ray D. Henson, instructor in engineering law at the University of Illinois, answers by paraphrasing an old saying: "United we can, divided we fail" (*pages 213–17*).

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Standards for Electrical Measurements. Some of the equipment used to make highly accurate measurements of standards for electrical units is described. These standards are based on absolute measurements that fix the relationship between electrical units and the mechanical units of length, mass, and time (*pages 202–06*).

Liquid Cooling of A-C Turbine Alternators. The method of cooling a-c turbine generators by means of hydraulic systems has been simplified greatly from the first designs. It has been possible to parallel all internal water systems, as well as to omit the external deaerator and the small ducts below the main slots in the rotor (*pages 218–23*).

Mechanism of Body Control. The human body may be likened to a servomechanism for studying simple behavior if psychological aspects of behavior are neglected. In this case, only movements which have become habits through a training process can be studied (*pages 207–12*).

Corona on High-Voltage Lines. Recently the effects of corona on high-voltage lines have been studied. Both fair- and foul-weather measurements were made and, because outdoor foul weather was not constant, laboratory tests also were made (*pages 224–30*).

Highway Mobile Telephone System. Studies of mobile telephone systems showed many ways in which service could be made faster and interference between stations reduced. Using practices initiated because of these studies, the number of calls which could be handled with little delay was doubled (*pages 236–41*).

Small-Diameter Submergible Pumps. Pumps for use in deep wells have been developed which have lengths up to 28 feet for outside diameters of the order of $7^{1}/_{2}$ inches. In manufacturing pumps, tolerances are held to 0.0005 inch for many pump and motor parts (*pages 242–44*).

Submarine Telephone Cable. Repeaters with a life expectation of at least 20 years have been installed in a recently laid telephone cable. Cables and repeaters were designed so that they could be laid with regular cable-laying machinery and would withstand elements on the ocean bottom (*pages 248–53*).

Deterioration of Transformer Oil and Paper. A recent study has shown that transformer oil changes with time and temperature whether or not it is exposed to oxygen. However, the presence of other materials will tend to cause acceleration of the deterioration of the transformer components (*pages 244–47*).

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions.*

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Feb '50, p 46A	Winter General
Jul '50, p 30A	Winter General North Eastern District Great Lakes District Summer and Pacific General
Nov '50, p 43A	Middle Eastern District Fall General

Community Dial Office Equipment. The low-cost dial office equipment used for small communities of sparsely settled areas is described this month. This type of equipment must be rugged and simple to install and maintain, and, as it operates unsupervised, it must have an adequate alarm system (*pages 231–34*).

Class-B Insulation in Nitrogen. In tests made on Class-*B* insulating materials it was learned that in nitrogen a 10-degree-centigrade rise in temperature will reduce life 50 per cent. However, with nitrogen surroundings the Class-*B* materials can be used at temperatures that require Class-*H* materials in air surroundings (*pages 257–58*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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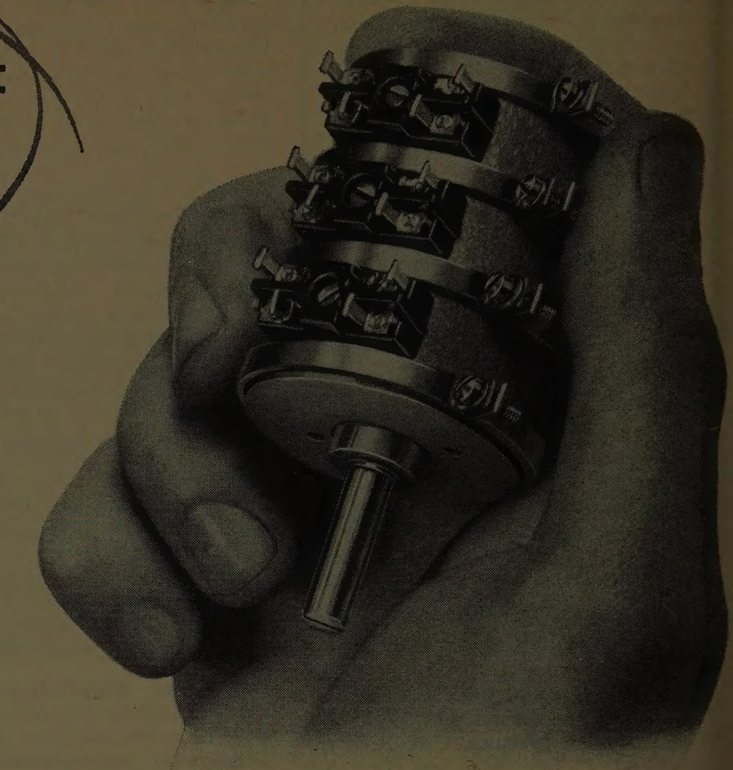
March 1951, Vol. 70, No. 3. Number of copies of this issue 56,400

Here's Fairchild's Newest Potentiometer!

TYPE-746
PRECISION POTENTIOMETER OFFERS:

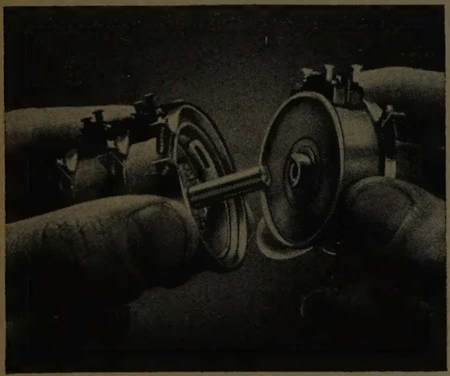
- **Low Torque**
- **Accurate Phasing**
- **Quick Replacement**
- **Ganging up to 20 on a shaft**



The finest we've ever built! That's our idea of the new "746". It's got lower torque, a new more accurate phasing adjustment, and a new method of ganging that makes it easy to put as many as twenty cups on a single shaft. Individual cups in a gang are easily replaced if necessary.

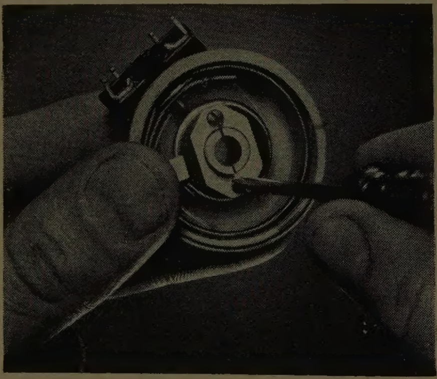
The new potentiometer is available with linear or non-linear windings to meet your specifications. Its attractive case is made of grey anodized aluminum.

The "746" is just one of the complete Fairchild family of precision potentiometers. What are your requirements? Write, giving details, to *Fairchild Camera and Instrument Corporation, 88-06 Van Wyck Boulevard, Jamaica 1, N. Y.* Dept. 140-13L.



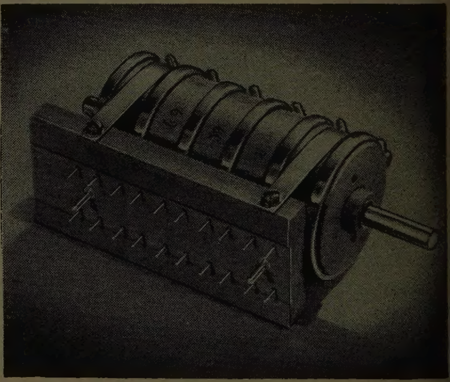
EASY REPLACEMENT

To replace a unit in a "746" gang, loosen connecting-band screws, remove "cup," slip new "cup" under bands, and tighten screws. This feature pays off in experimental work where circuit elements are changed periodically.



ACCURATE PHASING

A new type phasing adjustment is simpler and more accurate. A retainer plate clamps shaft to wiper arm. To adjust for phasing, loosen two screws, set the arm to the correct position, then tighten screws.



FLEXIBLE DESIGN

Typical of the special consideration Fairchild gives to its customers' special requirements is this plug-in version of the "746." Where fast servicing is a must, the advantages of this "quick-change" unit are quite apparent.

SPECIFICATIONS

Accuracy (overall resistance)—±.5% (linear), ±1.0% or better (non-linear)

Mechanical accuracy—
concentricity (shaft to pilot)—.0015 in. FIR max.;
radial play—.0009 in. FIR max.;
shaft—centerless ground stainless steel to .2500 diam. (+.0000, −.0005 in.);
pilot hub—machined to .5000 (+.0000, −.0005 in.)

Torque—1.5 oz-in.

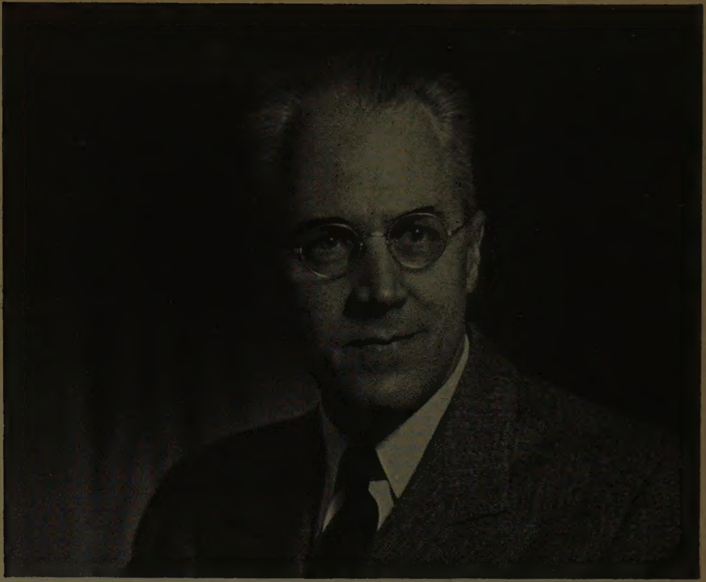
Dimensions—diameter 1.750 max.; length (1 cup) .800 in. ±.009 in.; added length per unit ganged .580 in. ±.002 in.

Case—grey anodized aluminum

FAIRCHILD
PRECISION POTENTIOMETERS

SEE THE TYPE 746 AND OTHER FAIRCHILD PRECISION POTENTIOMETERS AT THE RADIO ENGINEERING SHOW, BOOTH 238-239

Members and Money



T. G. LeCLAIR
PRESIDENT AIEE

THE BOARD OF Directors, at its regular meeting on January 25, adopted resolutions proposing two material changes in the Constitution. One of these anges is to establish requirements for various grades of embership consistent with those recommended by the ngineers' Council for Professional Development (ECPD). e other change transfers provisions for membership dues om the Constitution to the By-Laws. Within a few days, ch member of the Institute will receive a ballot covering ese changes. Your favorable vote is recommended.

MEMBERSHIP REQUIREMENTS

HANGES ARE proposed in the method of transfer to higher grades of membership, as requested by the ard of Examiners. In particular, transfers to the grade Fellow, hereafter, are proposed to be solely by invitation the Board of Directors, on commendation by five or ore Fellows or Members. imination of the method transfer by direct applica- n and raising of the stand- ds will make the Fellow ade more nearly honorary. At the same time, it was nsidered wise to take this portunity to review the requirements for all grades of embership in the light of recent developments.

The Board of Directors recommends that the Institute adopt membership requirements consistent with those of other societies and that dues provisions be transferred to By-Laws. AIEE President LeClair outlines reasons for these recommendations.

Several years ago the Committee on Planning and Co- dination recognized that unity in the engineering pro- sion must be based on a common understanding as to at constitutes an engineering society. They suggested possible series of grades of membership for this purpose. ur Board of Directors referred this suggestion to the PD for co-ordinating purposes, with a resolution that Institute would change its constitution to meet equiva- t levels of these, or any other, uniform grades of member- p recommended by ECPD and acceptable to other ieties. The proposed Constitutional amendments would make the Institute membership requirements more consistent with the ECPD recommendations, which have already been adopted in principle by other major societies.

The proposed changes in grade of membership include some increase in the experience and educational requirements for the Member and Associate grades. The changes include also the addition of an Affiliate grade, to provide for those persons interested in engineering and related activities who are interested in the Institute even though not engaged directly in engineering. This grade is intended to be nonvoting for general Institute offices.

DUES PROVISIONS

THE ADOPTION of the constitutional amendment to transfer dues to the By-Laws will mean that in preparing the budget for next year, the Board of Directors will be in a position to increase dues, if required by rising costs and additional services to members, but not before May 1, 1952. Under the present Constitution, an increase in dues, if found necessary, would normally be agreed upon in principle by the Board of Directors at one meeting and presented to the Board in constitutional amendment form at the next meeting. If approved, a ballot then would be sent to the membership on March 1 for vote. A favorable ballot would be reported at the annual meeting in June and could not take effect until the following May first. Consequently, any change in dues to meet unexpected conditions cannot be effective until $1^1/_2$ to $2^1/_2$ years from the date that the necessity arises. Under present conditions of rapid price changes and need for the Institute to be flexible in new services, this period is too long. If the Constitution must be changed to increase dues, the increase must be large enough to cover

---

T. G. LeClair is chief electrical engineer, Commonwealth Edison Company, Chicago, Ill.

contingencies for some time in the future. If, on the other hand, dues are transferred to the By-Laws where they can be changed on shorter notice, any dues increase need cover only current requirements. Be assured that if you place this confidence in the Board of Directors, they will do everything possible to see that you get excellent service at a minimum cost.

WHAT HAS HAPPENED

The 1945–50 period was one of tremendous growth, both in membership and in services rendered to the members. The end of the war, and the consequent removal of engineering material from classified lists, gave the Institute a well-responded-to opportunity to enlarge its technical activities. Between 1945 and 1950, these technical activities more than doubled. The adoption of the division method of technical committee organization has approximately doubled the number of technical committees as well as increased sharply the number of papers presented at meetings. The number of District meetings and technical conferences also has increased.

To furnish the increased services, there has been an increase in income from higher advertising rates and also from the substantial increase in the number of Institute members who pay dues. On the other hand, publication costs have increased very sharply. In an attempt to keep within reasonable limits, it has been necessary to present more papers in the form of Conference papers, District papers, or Advance-Copy-Only (ACO) papers, as illustrated in the following comparison between the years 1930 and 1950:

	1930	1950
Number of unpublished papers	32	433
Number of Transactions papers	167	238
Membership as of May 1	18,003	34,198
Net publications cost	$24,674	$110,381

The headquarters staff has instituted a number of practices for greater efficiency in handling the headquarters activities and the many other services necessary for an organization with such a large membership. The present efficiency of this staff is as good as, or substantially better than, that of any other comparable engineering societ

Registration fees are now required at General ar District meetings and at technical conferences. Th practice makes these activities more nearly self-supporti and assesses the charge on those who derive the greate benefit.

FUTURE PROBLEMS

As mentioned before, there is a definite need for th publication of a larger proportion of the total pape presented. The Publication Committee has been asked study this problem and will present a concrete recon mendation during the coming year.

Many of the Sections feel that their present appr priation is not adequate with the recent increases i costs for mailing of notices and for meeting room The Finance Committee will have to weigh their r quests against sources of income. To illustrate ho rapidly conditions may change: in the fiscal year en ing May 1, 1946, there was a material operating surpl as dues income increased more rapidly than service the expanded membership, but by the year ending in 194 this had changed to a material deficit resulting main from sharp increases in printing and other costs. Th Institute must be in a position to meet changes of th nature on reasonably short notice, as it does not hav a reserve adequate to stand continued deficits for sever years.

The Board of Directors recommends this change in th Constitution with the full knowledge that many membe will feel that other approaches to the problem may better. A surprising number of these proposals alrea have been discussed and weighed carefully. It is th considered judgment of your Board, after a full and fr discussion, that it is to the best interest of the membersh as a whole to ask that the dues be transferred to the B Laws rather than to request a substantial dues increa at this time.

PLEASE VOTE

Whatever your convictions on the recommend constitutional amendments, please mark and retu the ballot promptly. Remember that a 75-per ce affirmative vote is required for any amendment to pass.

Remember to Mail Your Constitutional Ballot

Otto B. Blackwell—Edison Medalist for 1950

The Edison Medal

J. B. MacNEILL
FELLOW AIEE

TODAY THE American Institute of Electrical Engineers presents the Edison Medal to a distinguished member for achievements in telephone transmission d related fields. This presentation is the 40th since the edal was originated in 1904.

Associates and friends of Thomas A. Edison conceived the lison Medal Association for the purpose of appropriately counting and celebrating the achievements of a quarter of century in the art of electric lighting, with which the name Thomas Alva Edison is imperishably identified. The lison Medal was established by this group in 1904 as "the ost effective means of accomplishing the object for which was formed," and to "serve as an honorable incentive to entists, engineers and artisans, to maintain by their rks the high standard of accomplishment set by the ustrious man whose name and features shall live while man intelligence continues to inhabit the world."

The AIEE accepted the responsibility of making the ards and has continued to do so through the Edison edal Committee of 24 members. This Committee holds annual meeting in the fall for the purpose of considering achievements of the nomies placed before them. All ndidates must be nomited, or renominated, for current year. No nomitions are held over to sucding years, but favorable cussion at one meeting y be helpful to a candite if he is renominated.

The Edison Medal for 1950 has been awarded to Otto B. Blackwell "for his pioneer contributions to the art of telephone transmission." This medal is awarded annually for meritorious achievement in electrical science or electrical engineering or the electrical arts. The presentation, the 40th since the medal was originated in 1904, is a fitting tribute to Otto B. Blackwell for his achievements in telephone transmission and related fields.

The bylaws of the Comttee restrict the award of medal to a resident of the ited States of America or its pendencies, or of the Dominion of Canada, whenever in judgment of the Committee such a resident is deserving he award, provided funds are available. The award is "meritorious achievement" in electrical science or trical engineering or the electrical arts.

he medal, designed by James Earle Fraser, carries on obverse the portrait of Thomas A. Edison and, on the erse, an allegorical conception of the genius of electricity wned by fame.

ince this convention has considered the transmission of tricity up to 500,000 volts, with corresponding distances, since the medalist is cited for achievement in telephone smission, it may be of interest to note a brief reference to early transmission possibilities as contrasted with modern practice. Dr. Elihu Thomson, in accepting the first Edison Medal in 1909, related the following early conception of electric transmission. He said: "As an instance of what was in the minds of people at the early inception of our art, I will read a little extract which I happened to find in one of the issues of the Gas Light Journal of 1878, when a discussion of the forthcoming Edison light, then the platinum wire lamp, was held. The following colloquy took place:

> Mr. D. The gas we are now burning comes from Birchington, a distance of $1^1/_4$ miles. Would it be possible for me, if I wished to do so, to send electricity from here to Birchington to give light there?
>
> Mr. G. It would be possible, but not economical.
>
> Mr. D. Then how am I to light Birchington?
>
> Mr. G. I should say, decidedly, take your machines to Birchington.
>
> Mr. D. What am I to do for light along the road between here and Birchington?
>
> Mr. G. Place machines at convenient distances.
>
> Mr. D. In other words, several stations in such a short distance.

That was the view of a gas man, and actually occurred at a meeting of gas engineers at the time reported, and will be found in the Gas Light Journal. I could go on and multiply instances of that kind, but that is merely a statement of conditions as they existed, and we have not time to go so far into ancient history."

The Medal Committee, in reporting to the Board of Directors in May 1910, stated: "It is believed that the administrative affairs of the Medal Committee have now been brought into such efficient and working order as to insure hereafter an annual award of the medal." With the growth of the electrical industry and its vast contribution to the industrial and cultural life of America, there have naturally developed a considerable group of scientists and engineers well qualified for consideration by the Committee. The problem is therefore one of selection. From such a group, the Edison Medal Committee is proud to have sponsored, by unanimous vote, the 40th award of the medal to Otto B. Blackwell as a fitting tribute to his achievements in telephone transmission and related fields.

Full texts of the presentation and acceptance addresses given at the Edison Medal ceremonies held during the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951.

J. B. MacNeill, Chairman of the Edison Medal Committee, is Manager, Switchgear and Control Division, Westinghouse Electric Corporation, East Pittsburgh, Pa.

The Edison Medalist

H. S. OSBORNE
FELLOW AIEE

In 1906 one of the graduating class at Massachusetts Institute of Technology was a tall, thin, soft-spoken boy from Bourne, on Cape Cod, Mass. This boy was destined to have the distinguished career which we are celebrating today.

At the time of graduation, young Blackwell, an honor student, had already attracted the attention of Dr. Frank B. Jewett, newly launched on the development of the telephone art and destined later to become an Edison Medalist. Doctor Jewett was attracted by Blackwell's honest and clear analytical way of thinking and speaking. Blackwell accepted Jewett's offer of $11.54 a week and went to work at once. He little imagined at that time that in the short space of eight years he would succeed Doctor Jewett as the head of a group of engineers responsible for a vast development of telephone transmission.

EARLY TELEPHONY HISTORY

In 1906, when Blackwell began his work, the Bell Telephone system served 2,000,000 telephones. Connections were principally within local areas. Quality of transmission was poor if judged by present standards.

Intercity service had been developed to some degree by the use of large gauge bare conductors on pole lines. The most important lines were built around the big cities, because going through the cities would mean going through sections of cable, and that would spoil the transmission.

A few years earlier the loading coil had been invented. With this great aid to transmission a toll cable 44 miles long had successfully been designed and placed in operation between Boston and Worcester. Construction work was under way on a still greater project, a cable between New York and Philadelphia 90 miles in length.

Three years earlier on open wire lines the first successful application had been made of the phantom principle by means of which three circuits instead of two were provided by a group of four conductors. No method was known for applying it to cables.

Radio-telephony was unborn and its possibilities not dreamed of.

PRESENT PICTURE

The contrast between that picture of 1906 and the present is striking. From any one of the 35,000,000 Bell telephones one can talk to any other one with good transmission. In fact, one can talk to 98 per cent of all tl 70,000,000 telephones throughout the world. Long-lin messages have risen from 25,000 a day to nearly 900,0 a day.

Underground toll cables cover the country and car the longest circuits, as well as shorter circuits, with excelle transmission. Radio-telephony has become an integr part of the telephone system.

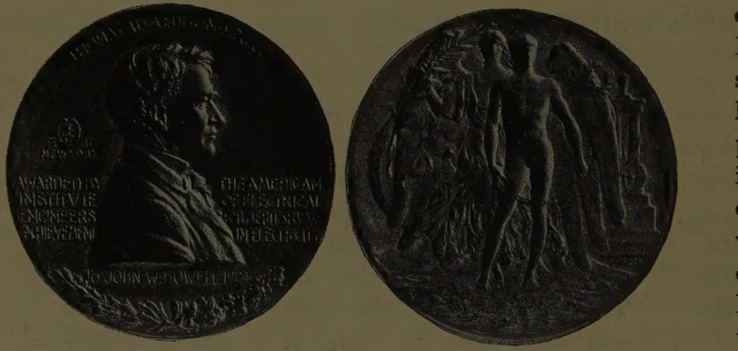
Better quality of transmission is not the whole story—i Siamese twin is lower costs of transmission circuits. In ci areas, in place of the 19-gauge and larger conductors 1906, general use is made of small gauges averaging on third the weight of copper. For intercity service, ope wires on pole lines have largely been replaced by cabl with conductors of 1/10th or 1/20th the weight. And the cable conductors, as well as the remaining open wire carry large numbers of telephone conversations over tl same wires using multiplex methods not known in 1906- some conductors carry as many as 600 simultaneous tel phone conversations.

A great many people have contributed to this revolutic in the telephone transmission art and the consequent va extension and growth of long-distance telephony. Probab no other living person has contributed as much as ou medalist of today.

TECHNICAL CONTRIBUTIONS OF MEDALIST

From the outset, Blackwell's technical genius produce results. He plunged into the problem of applying tl phantom principle to cable, thus increasing by half tl number of telephor conversations whic could be transmitte He contributed exte sively to the various prol lems involved. Nov processes were require in the manufacture of tl cables. New principl were introduced into tl design of loading coil Blackwell's greatest cor tribution, however, wa the conception of ne testing routines and spli ing methods to be use during the installation of the cable. He invented an built the sensitive testing apparatus necessary to appl the new methods. It was at that time a radical step to i troduce such a highly technical process in the installatic work. It was successful, and was necessary for the succe of the phantomed cable.

The new principles were applied immediately in tl construction of what was then a tremendous and nov project—an underground toll cable all the way betwe Washington and Boston, nearly 500 miles, connecting t gether the Capitol and the great cities of the Atlant seaboard.



The Edison Medal

H. S. Osborne is Chief Engineer, American Telephone and Telegraph Compa New York, N. Y.

Meanwhile Blackwell and his associates were making ther striking advances in the extension of long-distance ransmission. The immediate aim was to span the coninent. Developing the known art to provide the highest ossible efficiency, service of a sort was extended from New ork to Denver in 1911.

In 1912 Doctor Jewett was given a new assignment, laced in charge of the laboratories which have subsequently een named the Bell Telephone Laboratories. Shortly hereafter the job Doctor Jewett had left was assigned to lackwell.

I believe this early promotion was more of a surprise to lackwell than it was to his associates. But in one respect e had worked for it. In those days if a conference was eally important, there stood on the conference table a lass jar of large black cigars. All the big bosses smoked hem. It looked as though the ambitious young man ould have to learn to smoke those conference cigars if he oped to get anywhere in the business. Otto Blackwell ook to the weed, and in a surprisingly short time he was a ig boss.

PROGRESS IN LONG-DISTANCE LINES

IN HIS NEW job, and later in the Bell Telephone Laboratories, for nearly 25 years Blackwell was primarily reponsible for the wide and complex range of problems inolved in extending and improving telephone transmission. his was the period which witnessed most of the transormation which we have briefly summarized.

In order to talk from coast to coast it was necessary to use umbers of telephone amplifiers in tandem on the circuit. lackwell and his associates determined that this required asic changes in the construction and maintenance of longistance lines. New forms of repeater circuit were deeloped. By means of this work and the successful developent by the Laboratories of greatly improved amplifying nits and associated equipment, telephone service between he Atlantic seaboard and the Pacific coast was successfully naugurated in January 1915.

This great step proved not to be the end but only the eginning. Long-distance transmission was extended hroughout the country. New inventions and developments ade it possible to apply repeaters to underground cables f any length. Blackwell inspired his associates in this ork, and personally made important technical contribuons.

Carrier telephone systems were developed under Blackell's leadership. These systems provide multiplex transission over the same conductors, and have been a major ctor in the expansion of long-distance telephone service. he first system of this type was placed in service on open ire lines in 1918. The successors of this first system now pread throughout the open wire circuits of the country. ther developments under Blackwell's direction resulted in arrier systems for use on cables, both cables of ordinary onstruction and the more recent coaxial cable. The same rinciples are now being applied in long radio relay transission systems. At the present time 70 per cent of the 0,000,000 miles of long-distance telephone circuit in this ountry is provided by the use of carrier systems.

IMPROVEMENTS IN ENGINEERING PRACTICES

BLACKWELL was not only a leader in the spectacular development of new instrumentalities for long-distance transmission but also in the development of sound plans for the practical and economical design of telephone systems for good transmission results. In 1906, few transmission data were available to the operating telephone engineer. The theoretical background was there, but not developed for everyday use. Blackwell took the lead in organizing in form for practical use circuit theory, transmission data, and design procedures and in getting this information broadcast throughout the telephone system. These tools enabled the engineer to design the entire plant, for both local and toll service, in such a way that both economy and high transmission standards resulted.

Blackwell early realized that a telephone system designed to meet high transmission standards would not continue to give good service unless proper checks were made periodically of its performance. He invented and designed the first transmission measuring set for this purpose and inaugurated a system of transmission maintenance measurements which has been of untold value in maintaining transmission quality of the telephone plant throughout the country.

PROFESSIONAL ACTIVITIES

I HAVE SPOKEN particularly of Blackwell's contributions to the telephone art. In addition, he always had time for general professional activities. He served the AIEE in numerous capacities, including member and chairman of various committees. He was elected Vice-President for the term 1936–38. He served for years on joint committees of the Edison Institute and the Bell Telephone system in working out the problems of co-ordination between power and telephone systems.

Blackwell was my first boss in the Bell system. I can testify to the inspiration of working with him. His creative imagination and penetrating power of analysis made him a real leader. His intellectual honesty was infectious. His

Edison Medalists

Elihu Thomson	1909	E. W. Rice, Jr.	1931
Frank J. Sprague	1910	Bancroft Gherardi	1932
George Westinghouse	1911	Arthur E. Kennelly	1933
William Stanley	1912	Willis R. Whitney	1934
Charles F. Brush	1913	Lewis B. Stillwell	1935
Alexander Graham Bell	1914	Alexander Dow	1936
Nikola Tesla	1916	Gano Dunn	1937
John J. Carty	1917	Dugald C. Jackson	1938
Benjamin G. Lamme	1918	Philip Torchio	1939
W. L. R. Emmet	1919	George Ashley Campbell	1940
Michael I. Pupin	1920	John B. Whitehead	1941
Cummings C. Chesney	1921	Edwin Howard Armstrong	1942
Robert A. Millikan	1922	Vannevar Bush	1943
John W. Lieb	1923	E. F. W. Alexanderson	1944
John W. Howell	1924	Philip Sporn	1945
Harris J. Ryan	1925	Lee de Forest	1946
William D. Coolidge	1927	Joseph Slepian	1947
Frank B. Jewett	1928	Morris E. Leeds	1948
Charles F. Scott	1929	Karl B. McEachron	1949
Frank Conrad	1930	Otto B. Blackwell	1950

keen sense of humor and dry wit and his unfailing consideration for all made it a great personal pleasure to work under his supervision or to collaborate with him. He was not only our leader, but was and is our cherished friend.

Otto Blackwell, speaking for all of your associates, I salute you as a great pioneer in the development of the telephone art, and also as a man and as a friend.

Science and Human Relations

OTTO B. BLACKWELL
FELLOW AIEE

I AM VERY deeply moved by the award to me of this Edison Medal with all its significance in the electrical engineering world. A medal which commemorates the genius of Thomas A. Edison. A medal which has gained added values during 40 years from the outstanding men who have received it. In the Bell Telephone system we remember that the sixth award was to Alexander Graham Bell. This was later followed by awards to John J. Carty, Frank B. Jewett, Bancroft Gherardi, and George A. Campbell. Every part of the electrical engineering world is similarly represented by notable people. It is indeed a great honor to have one's name appear on a roster of such men. With great appreciation, I thank the Institute which through its medal committee placed my name there.

Otto B. Blackwell is shown receiving the 1950 Edison Medal from AIEE President LeClair

I am much indebted to Mr. Osborne and many ot engineering friends for their messages of congratulation a good wishes. Their kind words have almost persuaded that I really deserve the medal—a very happy state of m for today. Tomorrow, when I look at the medal, I sh ponder on many things. Perhaps the great persuas power of some of my friends. Surely I shall recall the ma men who contributed largely to the work for which I fortunate to be in a position to now receive this mec I shall think with pleasure of the great responsibilities carried by some of these former close associates and h much more advanced and wonderful is the work they now doing compared to the work of my day.

PROBLEMS OF HUMAN RELATIONS

A MEDALIST is allowed a short time during which h expected to say something important, or failing th at least something interesting. The most important matt I know today are the appalling problems of human relati which confront us. A man who has had the experience seeing and feeling the power of large scale, properly staf and organized scientific investigation naturally wond what a similar approach would do to the problems of hum relations. It is hardly a subject for a 15-minute discussi But I would like to make a few passing comments on so reading I have carried out recently which relate to it.

I do this with many misgivings because the only propo tion on which all philosophers appear to agree—and we add some economists and even an occasional busin executive—is the artlessness of the engineer and scien when they step outside their special fields. Many years I was in a small group who dined with a very compet economist the day he addressed a session of the AIEE. told our small group that he considered engineers the th worst and scientists the second worst in presenting fool ideas about the betterment of social conditions. B arose, he said, from a lack of realization of the complex of the problems involved. But then he smilingly admit that the number-one worst offenders were certain gro of economists who didn't agree with his own ideas.

I found constantly emphasized in my readings t science cannot possibly deal with human values in lif for example, can never tell us what we ought to do. W an artlessness which should please our philosopher crit I started to test this by looking up in the Columbia Encyc pedia the subject of sin. The one-fifth page I found seem a rather inadequate coverage, even for a 1-volume auth ity, of such an important and interesting subject as t But it told me that gluttony had been rated as one of seven capital sins. Surely here, I thought, was a sim case in which to determine what we ought to do: we wo go to medical science to find where eating reached the po of injuring the health. Then I read a well-known aut who stated categorically that health was really just animal ideal and that it was more normal for spiritual m to be ill than to be in good health.

But most of the philosophers admitted, rather reluctan it seemed to me, that if, in some way quite separate fr

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Otto B. Blackwell is Assistant Vice-President (retired) of the American Telephone Telegraph Company, New York, N. Y.

cience, ideals are established, then science can be very nelpful in reaching them. So I proceeded to read along his line.

Some years ago an investigator reported that when he ed to certain laboratory animals a diet completely acking in a particular chemical element, the females lost ll interest in their young. So the humorists immediately imagined a solicitous human mother, tired and narassed with her children at particularly trying periods, calling her doctor for just a few more pills containing this mportant element. It isn't quite as simple as that, but just recently the daily papers contained reports of an investigation showing that the part of the brain where emotions are centered produces a hormone which stimulates other glands and that this promises a new approach to all manner of ills of body and mind associated with the emotions.

Man has been impudently but uniquely defined as the animal which laughs. Since laughter is so uniquely associated with man, it must have a special significance for us. I can foresee large organizations of very serious men assiduously investigating what we call our sense of humor and now it is excited and satisfied. Such organizations should at least have the support of the amusement world from Hollywood to Broadway and might even obtain government unds if the legislative and executive departments could be assured of some way of getting back at cartoonists, columnists, and radio commentators.

Frequently it is not evident how to approach human problems since people cannot be handled like electrons or aboratory animals. But competent investigators can find many clues. Perhaps the most amazing article I have read uggests that in a few generations or less, the question of now much freedom of the will man possesses will be taken out of the hands of the philosophers and answered with a high degree of probability by scientific investigation. The method is by comparison of what happens to identical twins under different conditions. Some data already available uggest the power of heredity is very great. In recent years he tendency has been to emphasize the power of environment. Where both heredity and environment are set heavily against a man, it may be more of an accomplishment for him to just lead a decent life than for another with avorable inheritance and surroundings to make a great uccess—perhaps get a medal. The article further suggests what many of us could have predicted from quite non-scientific observation, that the most powerful of all environmental factors is a good wife.

SCIENTIFIC APPROACH TO HUMAN PROBLEMS

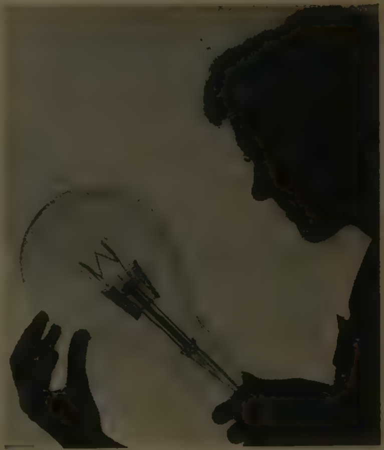
I GATHER from my readings that very brilliant work is being done on the scientific approach to human problems but surely not at all in proportion to its importance. In the further comments I shall make, I am treading on ome dangerous ground for an amateur philosopher, but till I will venture to proceed.

Such scientific work evidently must overcome many prejudices. There is good reason to be concerned that improper conclusions will be drawn from incomplete data. This needs more and better, rather than less, scientific work. I can sympathize with the fear that facts may become well established, such as about the freedom of the will, which are incompatible with what we like to believe. Such adjustments have been made before. Few would take the position of not wishing to know the truth. Surely science should not supplant but supplement the agencies now working effectively for our betterment. I see no reason why our attitude to such work should be very different whether we think of personality as a product of evolution or as something quite outside evolution and eternal, but now acting through human bodies and minds and so hampered and hurt by the heavy forces of heredity and environment.

Nearly everyone welcomes the scientific work done in helping children develop normally and fully. The quotation "Men are but children of a larger growth" is both good literature and good science. We develop a great deal intellectually as we become adults but our emotional progress is not very marked. And emotions are the driving forces in our lives. The pleasantest use of the intellect is in rationalizing the actions our emotions bid us do. We are now told that whether an infant is loved and petted and given a sense of security may radically affect his whole adult personality. Incidentally, one author discussing this remarked that science had finally discovered love. In toys and games the adult and child are not far apart, nor are other appeals to our emotions, for example in advertising and politics, at a much higher level. I have no great desire to change this even were it possible. In fact, most of us particularly like people who don't feel very grown up and can smile at themselves. It is men who haven't grown up emotionally and don't know it and cannot be told who are dangerous. Just now the world's emotional children are playing with fire.

Surely everyone should welcome whatever the intellect of man can find to help his emotional childishness. "The proper study of mankind is man" is more completely true today than when it was written. And a study with every technique and tool that man can devise, and in coverage and intensity commensurate with its importance.

New Lamp for Outdoor Sports



A new 1,800-watt sports floodlamp has been announced by Westinghouse Lamp Division. It features a collector grid above the filament that collects the vaporized tungsten that normally deposits on the inner surface of the bulb with a resultant gradually increasing absorption of light. The lamp at the end of its life will still produce 81 per cent of the initial beam lumens as compared with 59 per cent for similar lamps. The 1,800-watt lamp is rated at 117 volts. The rated average laboratory life of the lamp is 300 hours.

Karl Taylor Compton—Hoover Medalist for 1950

Karl Taylor Compton

Scientist, Educator, Humanitarian

C. G. SUITS
FELLOW AIEE

NO NAME IN the entire roster of contemporary American scientists shines with a brighter luster than that of Karl Compton. As a research physicist, he has made outstanding contributions in a number of fields. As a distinguished educator and university administrator, he has played a leading role in the integration of fundamental science and technological training. As one of the leaders in the mobilization of science for war, his varied wartime services have placed the entire country in his debt.

Scientist, scholar, leader, humanitarian—all that these terms imply, and more—is Karl Compton.

THE MEDALIST

KARL TAYLOR COMPTON was born in the small college town of Wooster, Ohio, in 1887. His father was Elias Compton, professor of philosophy and for many years Dean of the College of Wooster. His mother was a brilliant and energetic woman who a few years ago was nationally honored as the "American Mother of the Year." She also was granted a Doctor of Laws degree by Western College for "outstanding achievement as a wife and mother." Other members of this distinguished family of scholars, which includes three university presidents and the wife of another, are Arthur H. Compton, Chancellor of Washington University in St. Louis, Mo., Wilson Compton, President of State College of Washington in Pullman, Wash., and their sister, Mary Compton Rice, wife of the President Emeritus of Forman Christian College, Lahore, Pakistan. The eldest son, Karl, set the mark for his brothers and sisters by becoming President of the Massachusetts Institute of Technology in 1930.

The Hoover Medal for 1950 was awarded to Karl Taylor Compton, Chairman of the Corporation of Massachusetts Institute of Technology. The medal is a joint award of the AIEE, The American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Society of Civil Engineers; Doctor Compton is the 12th recipient of this medal "to a fellow engineer for distinguished public service."

PROFESSIONAL CAREER

BUT LET ME take up the story of Karl Compton's life and achievements in a more or less chronological order. His academic life began in the College of Wooster from which he received his Bachelor of Arts degree in 190 and his Master of Arts degree in 1909. After one yea as instructor in chemistry at his alma mater, he entered th graduate school of Princeton University where he studie under O. W. Richardson. After receiving his Doctor c Philosophy degree in 1912, he joined the faculty of Ree College, Portland, Oreg., where he was instructor i physics for two years. From Reed College he returned t Princeton as assistant professor of physics. During Worl War I he devoted his scientific talents to war problem serving first as aeronautical engineer for the Signal Corp and later as scientific attaché at the American Embass in Paris.

At the conclusion of the war, Doctor Compton returned t Princeton as a full professor, later becoming Head of th Physics Department. It was during these years that h engaged in extensive and significant researches in photoelectric phenomena, thermionic emission, fluorescenc the dissociation of gases, the investigation of crystal structure by X rays, spectroscopy in the extreme ultraviole and in varied other fields of physics. His work on electrica discharges in gases was important both because of its bearin upon fundamental problems of atomic structure and because of its practical application to the use of gas discharg as sources of light. Compton's researches in spectroscop played an important role in establishing experimentally th fundamental hypothesis underlying the Bohr theor

Doctor Compton is the autho of more than 100 technica papers, not including thos publications of his studen in which he had a han Many of our leading younge physicists of today owe the start in research to the guidance and counsel of Ka Compton.

In 1930 Doctor Compto was elected to the presidenc of the Massachusetts Inst tute of Technology (MIT), post that he filled with distinction for 18 years. Eve when actively engaged in fundamental research at Princ ton, he had been keenly interested in technological d velopments and in the training of men to meet the tec nological requirements of a scientific age. He was, ther fore, a particularly happy choice for the chief administrat of an institution dedicated to the wedding of science a technology. In spite of his extensive administrative r sponsibilities, Doctor Compton maintained personal conta

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Full texts of the presentation and acceptance addresses given at the Hoover Me ceremonies held during the AIEE Winter General Meeting, New York, N. Y., Janu 22–26, 1951.

C. G. Suits is Vice-President, General Electric Company, Schenectady, N. Y.

with research in physics and continued for many years to supervise his own program of experimental work in spectroscopy in the MIT laboratories. The fruits of Doctor Compton's administrative and scientific leadership at MIT are recognized the world over. Primarily because of his vision and ceaseless efforts, the Massachusetts Institute of Technology rose to a position of academic pre-eminence among educational institutions of the world.

SCIENTIFIC SOCIETIES

Doctor Compton's academic life has encompassed a wide range of interests, and he is an active member of all of the leading American scientific societies. Among the responsible positions that he has held in the scientific societies are: President of the American Association for the Advancement of Science (1935), President of the American Physical Society (1927–29), President of the American Society for Engineering Education (1938), and Chairman of the Division of Physics of the National Academy of Sciences (1927–30). He was recently elected President of the Scientific Research Society of America. As a trustee of numerous foundations and educational institutions, he has contributed his rich experience and wise leadership in many phases of American progress. The most recent count that I have been able to make indicates that he holds honorary degrees from 28 institutions of higher learning. He is a member of Alpha Tau Omega, Tau Beta Pi, Sigma Xi, and Phi Beta Kappa.

Doctor Compton's activities as a public servant include distinguished duty on a long list of government boards, commissions, and committees. Through these activities, he has constantly sought to bring the weight of scientific knowledge and the force of the scientific method to bear upon problems of public concern. In giving unsparingly of his time and talents Doctor Compton has made important contributions to the public welfare.

Karl Taylor Compton

During World War II, Doctor Compton was one of the foremost scientists devoting their energies to the concentration of scientific and technological effort upon the problems of war. The organization charged with the co-ordination of scientific effort and military requirements was the Office of Scientific Research and Development (OSRD). Doctor Compton was a member of the National Defense Research Committee of OSRD throughout its entire existence (1940–47). He also served as Chief of the Office of Field Service, Director of the Pacific Branch of OSRD, and a member of the Scientific Intelligence Mission to Japan in 1945. Among the many other wartime institutions with which he served were the Naval Research Advisory Committee, the Research Advisory Panel of the War Department, the War Resources Board, the Committee on New Weapons of the Joint Chiefs of Staff, the United States Radar Mission to the United Kingdom, and the Secretary of War's Special Advisory Committee on the Atomic Bomb. In 1948 Doctor Compton resigned as President of MIT to accept the chairmanship of the newly created National Military Establishment Research and Development Board, a position that he held until his resignation in 1949. He continues to serve as Chairman of the Corporation of Massachusetts Institute of Technology.

HONORS AND AWARDS

The list of honors and awards that have come to Doctor Compton is an imposing one.

In 1931 he was awarded the Rumford Medal by the Academy of Arts and Sciences for contributions to the fields of spectroscopy and thermionic emission.

In 1946 he received the United States Army Medal of Merit "for exceptionally meritorious conduct in the performance of outstanding services to his country." This is the highest military award that can be bestowed upon a civilian.

In 1947 he received the Washington Award of the Western Society of Engineers and the Marcellus Hartley Public Welfare Medal of the National Academy of Sciences.

In 1948 he became an Honorary Commander of the Order of the British Empire, and in the same year he was made Commander of the Royal Norwegian Order of St. Olav.

In 1949 he was awarded the Lamme Medal of the American Society for Engineering Education.

In 1950 he was the first recipient of the Procter Award of the Society for Scientific Research.

The exposition of Karl Compton's exceptional abilities and the list of his outstanding accomplishments would be incomplete without a word about his human qualities. He is universally beloved by his associates and colleagues. To know him is to feel almost at once his friendly sincerity and the warmth of his personality. Although nature occasionally endows an individual with an exceptional talent, it is rare indeed to find in a single man the physical insight and knowledge of the outstanding scientist, the judgment and leadership of the great administrator, and the intensely human qualities of Karl Compton.

It is an honor indeed to represent my associates in the American Institute of Electrical Engineers in paying tribute to this great American, Karl Compton.

Engineers and National Security

KARL T. COMPTON
FELLOW AIEE

NO ONE COULD help but be deeply appreciative of the honor of being selected as a recipient of the Hoover Medal. Few, if any, of the recipients will have had such reason as I for a feeling of humility when we compare our attempts to serve our community and nation with the high standards set by the donor of this medal, Conrad N. Lauer, and by the great American, Herbert Hoover, in whose honor the medal was named and who was its first recipient.

A few years ago I was privileged to attend a very large, informal gathering of men of all shades of opinion from all parts of the country, where Mr. Hoover was to make an address. I shall never forget the thrill of his introduction as "America's most respected and beloved citizen, Herbert Hoover," or the great applause which followed this simple but adequate statement, more eloquent than any eulogism. There are those who may not always agree with him in his political or national policies. There are no men of good will who do not respect his unswerving and unselfish and effective service to his country and to mankind. I am proud indeed to be inducted into the brotherhood of the Hoover medalists.

Pleasant as it is to give and to receive acclaim, I have no doubt but that the chief purpose and value of the Hoover Medal are to create occasions in which the spirit of unselfish service, by professional men, to their society and their country can be emphasized in the public mind. In other words, I would say that the purpose is educational and inspirational, in that the medal and the medalist are like lenses whose function is to focus attention on the basic objective.

May I say just one other thing, before turning to the topic of my address? Unlike most of the previous medalists, and unlike most of you, I am not a real bona fide engineer. Probably no licensing board would give me a permit to practice the profession. I am only an engineer by adoption, and for the associations which have made this possible I am extremely grateful. These associations, both personal and occupational, have been so much a part of my career that I cannot but feel that, in receiving this Hoover Medal, I am receiving it on behalf of some hundreds of engineers and scientists who have constituted the various teams on which I have played this game of public service, and it is those teams which have made the achievements. I should like to mention just a few of these.

ENGINEERING ASSOCIATES

THE FIRST engineer who left a great imprint and inspiration on all my future career was Dr. W. F. Durand—close personal friend of Mr. Hoover and now Emeritus Dean of Engineering at Stanford University. I was his assistant in France during World War I. No man could have had that personal contact with him without absorbing something of his spirit of scientific honesty, engineering courage and competence, complete devotion to duty, and with it all a sensitive spirit of courtesy and sympathy. His was the basic gift of the great teacher, the unconscious ability to arouse in his associates the spirit of "go thou and do likewise."

Then, when I made my decision to cast my lot with the Massachusetts Institute of Technology, I took the plunge into an engineering environment which has been filled with stimulus and opportunity, again with the invaluable accompaniment of kindred souls as team-mates in new enterprises.

Shortly thereafter came a new opportunity, in which a number of you in this room participated. It started out as just another chore which somebody had to do. It was the program of accrediting the engineering schools of the country in order that the existing state laws for the licensing of engineers could be rationally administered. I suspect that few of us who worked on the development and introduction of this accrediting program had any wild missionary zeal for accrediting as such. At least I personally would have rather been doing other things. But the job had to be done, and it was important that it be done as well as possible. So it was undertaken under the auspices of the newly formed Engineers' Council for Professional Development. But it proved to be an exceedingly interesting undertaking and the results were satisfying. But the thing which most impresses me as I look back on that experience is the new group of personal friendships and institutional associations which grew out of this work. I mention this episode for two reasons: it was the occasion of my first close contact with this great professional society, the AIEE, and the sister engineering societies; and it illustrated the interesting point that jobs undertaken from a sense of duty, and perhaps reluctantly, very frequently pay an extra dividend of fine new friendships. One reason for this is that people who are found on such jobs are naturally unselfish, loyal to causes and ideals, good workers and co-operative. Such people make good friends.

Finally there came World War II, with its mobilization of scientists and engineers to develop and produce and use the materials and devices on which our national safety so critically depended. Here, in the close associations and in the necessity of getting results, scientists and engineers came to understand and appreciate each other as never before. They learned to work together in teams. Sometimes the distinctions between them were completely lost, because they were found doing the same things in the same way. Sometimes the distinctions between them were put to good use by appropriate division of labor. The

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Karl T. Compton is Chairman, Corporation of Massachusetts Institute of Technology, Cambridge, Mass.

engineers learned that at least some highly theoretical scientists hatched out ideas of tremendous practical importance. The scientists learned that engineers could do some things better than they could, especially when it came to getting ideas translated into physical form suitable for production and field use. To me, as to very many of you, this was a vivid experience and one which emphasized the significance of teamwork as no other experience in our history.

My reason for giving this personal slant to my introductory remarks is not only because the award of a medal has a personal interest, even though the happy recipient is far less important than the principle of the thing. These personal experiences serve to illustrate a very important factor in the problems which concern the subject announced for my address: "Engineers and National Security." But before I tackle this subject, perhaps I had better explain that it is a misnomer. When I tried to put down on paper what I had in mind, when I sent the proposed subject to President LeClair, I found that I was setting out to write a book rather than an address. So I decided not to inflict on you several years of pent-up ideas about how scientists and engineers could be better used to save the world, and started afresh on some thoughts which I hope are more appropriate and which certainly will be more briefly expressed.

PROBLEMS OF LEADERSHIP

As I GET occasional glimpses of the efforts which are currently being made to organize and direct our nation's technological strength for the national security, there are many, many problems at many echelons. Some of these problems relate to the impacts of science on international relations and policy; some relate to military strategy; some relate to the continuing strength of our economy; some relate to the selection of priority objectives for research and development and production; some relate to the technical methods for carrying these things through to realization and use. One thing which all these problems have, as a common denominator, is that their successful handling depends entirely on the ability to find men capable of handling them.

In the experiences which I mentioned previously, in World War I, at MIT, in the surveys of the engineering schools, in World War II, the most difficult and most continually pressing problem was to find the people who were competent and available to do the jobs. The more important the situation is, the more does this problem of man power stand out as number one in time, in importance, and in difficulty.

Even before the international situation became as acute as it is at present, I had striking evidence of the persistence of this problem. Last April I attended the meetings of the National Academy of Sciences in Washington. It was my first visit to the city since I had been forced by health to resign six months earlier from the chairmanship of the Research and Development Board. I took one day off from the scientific meetings to visit the Research and Development Board's offices, dropping in to see my friends and former associates. It was an interesting and heart-warming day, but the feature of it that made the vivid impression on me was this: without exception, when I would get up to leave one friend's office to go to another, he would say: "Can you stay for a few minutes to talk business? We need some one to handle such and such a job, and we have not been able to find a person who seems to be just right for it, and who is available. Can you give us any suggestions, or can you help us to get so-and-so made available?"

This is just one line of voluntary public service, and just one of many agencies, and the episode occurred before the Korean war had destroyed the fabric of hope and wishful thinking which had shielded us from the grim realities that are now so unmistakable. By this time the situation has changed in several respects. The emergency program now in process of activation is calling for the services of many more men. The situation is now sufficiently serious to give such service a high priority, as men try to decide what they should do, and to that extent it is now possible to command the services of men who were unavailable six months ago. But still the number-one problem is to find the men to do the jobs. I have participated in many policy and planning conferences during the last couple of months in MIT, Washington, and New York, and it is no exaggeration to say that the search for the right men to do the jobs which are clearly outlined is the major hurdle to be surmounted if these jobs are to be done effectively.

The public is prone to think that money is what gets things done. Congress passes laws to accomplish objectives, and establishes organizations on paper and appropriates funds to implement these laws. All this is necessary and proper. It gets publicity and the public feels that the job is in hand. If, later, it learns that the job, which its Congressional representatives ordered done and for which it is paying through taxes, is not proceeding satisfactorily, a great hue and cry may be raised. But back of the scenes there may very well have been the failure, in spite of strenuous search, to find the people qualified to get the job done. I have often felt sorry for the head of some governmental agency, even up to the President himself, when he has been criticized for making an ineffective appointment, and when I have known that man after man to whom the job has been offered has refused to take it.

The serious bottlenecks to American accomplishment, whether in public affairs or in private business, are not lack of funds but lack of the proper quality of man power. There is a profound difference between dollars and men. All dollars, provided they are not counterfeit, are alike and interchangeable; men are not alike and, the more important and difficult is the task for which they are needed, the less are they interchangeable. If the emergency becomes great enough, dollars can be turned out on the printing press or by equivalent means; men cannot be turned out to order, and Nature has set a delay period of a couple of decades at least before new people of economic or security usefulness could be made available, even if the order to produce an increased supply went out and were obeyed. In other words, any monetary bottleneck can be broken open if the emergency is serious enough to justify the means for doing it: however, there is absolutely nothing which can be done quickly to get around a basic dearth of human talent.

KEY PEOPLE FOR KEY JOBS

But let us examine more closely this question of finding key people to handle the key jobs. In reference to any given task of major importance, there appear to be three basic questions as to its leadership: (1) Do men of the necessary qualifications exist? (2) How can these men be found? (3) If found, how can they be secured? On each of these questions so much could be said and argued that I shall not even attempt the task, but I will ask you to have them in mind as I make the following general observations.

1. As I have heard the suggestions of men of scientific and engineering background for key posts in the present mobilization, it has been notable that the same names are discussed over and over again for the various positions. Their number is not large. They are generally in the same age range as were those who led in similar positions of responsibility a decade or less ago—old enough to have achieved experience and recognition and still young and vigorous enough to stand the exacting demands of a national emergency program.
2. Undoubtedly there are others who have the inherently desirable qualifications. Their discovery is the major problem. Perhaps they have not been discovered simply because they have not been engaged in similar activities, or associated with those who have been thus engaged. This in itself is a handicap not only to their identification, but also to their quick effectiveness if they were to be put on the job.
3. Of course, there really are a lot of people who would take these jobs. Many have actually applied for some of them, or otherwise asked to be used. Probably some of these people would do very well. But the real responsibility for filling the positions of high importance is to be as sure as is humanly possible that the person put into the position be qualified to handle it effectively. This takes more than willingness. It takes qualities of training and experience, built into native character, and previously demonstrated.
4. Census lists, rosters, psychological tests, and other guides for personnel selection have useful functions, but such values are more pertinent to the availability and selection of large groups than to the selection of individuals for key posts. The most effective organizations during World War II were built up by first selecting carefully the top leaders, letting them recruit the next level from among their professional acquaintances, and letting these in turn fan out to complete the organization. No punch card lists or file of information can compete with judgment based on personal knowledge in the recruitment of a coherent, hard-hitting team.

From these comments, you will gather that I am convinced that the creation of a new organization, to be effective, must be a highly personalized affair. The provision of the top echelons of leadership is not a process that can be dealt with in terms of broad categories or rules. The requirements are too sensitive to be handled effectively on any such basis. It is only at the so-called lower levels, sometimes improperly called the "working levels," that men become interchangeable units within large categories, and that they can be usefully selected or assigned on the basis of descriptions and job specifications.

CHANCES FOR PROMISING YOUNG MEN

What, then, can we do to secure the desired leadership beyond hunting for it? At least one thing we can do in a manner which proved extraordinarily fruitful during the emergency of World War II. This is to give promising young men the chance to develop and demonstrate the desired qualities. It is a very striking fact that so many of the men who are today recognized as having the qualities of scientific leadership and engineering administration are young men who were "discovered" and who discovered themselves through having been thrown into positions of responsibility in the exigencies of World War II, and who otherwise might have remained undeveloped and undiscovered.

As a positive suggestion, therefore, I would advocate a conscious effort to find promising young men and try them out in jobs of increasing responsibility as they show possibility of discharging it. This is a process of both education and selection which is a regular policy in many forward-looking companies. It is not a policy in all, and in academic circles has generally had to await what we call "openings." Can we, in our various organizations, not do more than we have been doing to develop and identify leadership talent? I am sure we can. This may turn out to be far more significant in the final outcome of our present national emergency than the much more publicized handling of selective service or draft.

While such a policy is justified in peacetime, it is especially important in times of emergency, like the present, when many new activities have to be started or expanded. I have often thought of one aspect which has been a natural and, on the whole, an unfortunate trend after a war. The war closes with a peak number of experts of various types who have demonstrated unusual value to the war effort. In this respect we emerge from the war strong. But the tendency is to continue to depend on these men overlong for leadership in their fields of interest to national security. After a few years they have become too old, or too out of touch with the younger men who are coming along as the active contributors in their fields. To help overcome this tendency toward obsolescent leadership in the field of military technological developments, for example, the Research and Development Board under Doctor Bush's leadership established the policy of limited terms of service on its various technical committees. The membership of these committees started out almost completely composed of men who had been prominent in their respective fields during the war, but the plan called for a gradual replacement with new and usually younger talent, so that new generations would gradually become acquainted with the problems and be tested as to performance.

Such a plan is certainly basically sound. It has worked airly well, although there have been some complications hich have nothing to do with this factor in the situation. ut even in this specialized and highly organized area, nd in spite of its professional interest, it has still proved ifficult to get the desired personnel.

DETERRENTS TO ACCEPTING JOBS

AN ENTIRE additional lecture, and more, might be devoted to the question: "What deters men from ccepting jobs with government agencies, and which of he deterrents might be removed by reasonable changes n the conditions of employment?" In times of great mergency the force of these deterrents is often overcome y the urge to render service. I shall not try to discuss his aspect of the problem, except in one rather philosophical spect about which I have been thinking recently, along the ollowing lines.

Probably all of us have felt a very significant difference n our attitude toward our "duty" in the past five years s distinguished from our attitude during World War II. hen every good man and true had to ask himself only one uestion when called upon to make a decision regarding is course of action. This question was: "Is this the ac- ivity open to me which enables me to make my most seful contribution toward the winning of the war?" ince that time, however, the issues on which individual ecisions are based have usually been far less clear-cut, nd the decisions correspondingly more difficult. For xample, long-term versus short-term issues; relative eight of responsibility to various good causes, including hat to one's own family, things of that sort. Here, I think, one of the basic problems facing our country, and one hich must be realized and dealt with constructively if e are to maintain ourselves against the threats from ithin and without against the "American Way of Life" hich we prize so highly.

In conditions of extreme emergency or peril, single-indedness of purpose is automatic and is the pattern for rvival. To a starving man, food is the overpowering bjective; to a drowning man, air; to a man in a burning uilding, escape. To a community struck by hurricane flood, salvage and relief become the immediate concerns. o a nation threatened with conquest, defense for survival nites all classes and political groups. By such concentra- on on a single basic objective, the probability of gaining is objective is maximized.

But in our complex peacetime "American Way of Life" ere are a multitude of legitimate objectives, each com- anding the concern and allegiance of large segments of ur population. The labor movement, education, re- gion, various aspects of social security or of social service, ew business enterprise, objectives of political groups, dustrial production, community planning and develop- ent, and a host of other interests all illustrate what I am ferring to. In addition to such broad objectives, every rson has his own legitimate ambitions and career and e welfare of his family to consider. When all these ings are added together we realize why it is difficult for to react quickly and effectively when a new emergency ises.

It is as though we were members of a football team, and our objective was to tackle the opponent. Every one of our current interests is running interference for that opponent. Only if we can crash through this interference can we hope to make the tackle.

In this respect, we are at a disadvantage with the Communists. They have a very simple formula: "Smash the capitalistic imperialists; then the world is ours." They make this simple formula stick because of two factors: their leaders keep repeating it until it registers with something like hypnotic effect; furthermore, their people have such a relatively simple life, being largely ignorant and underprivileged people of the masses, that there is not so much competition among objectives. Their leaders have to crash through relatively little interference to raise, for example, an army of Chinese "volunteers" to drive the capitalistic imperialists out of Korea.

A PARADOX

HENCE WE HAVE an apparent paradox: the very high state of our civilization, which we describe as the "American Way of Life" and which is characterized by initiative, specialization, education, social responsibility, and high standard of living, carries with it a sort of interference or inertia which prevents us from reacting as wholeheartedly and quickly as we might otherwise do in an emergency. There is a conflict of interest, and this conflict is often compounded with wishful thinking. I believe that these are some of the factors which induced our overprecipitate demobilization after World War II, which deterred us from adopting a policy of universal military training while there was yet time, which have made us so slow to accept the reality of the mounting program of Russian aggression and to take effective measures against this agression.

Apparently our situation has to become desperate before we begin to realize that it is dangerous. Only then are we willing to subordinate interests of lower priority to those more directly related to the basic issues of survival—at least, the survival of the kind of a world that we have helped to create and hope to enjoy.

Let me give you a current illustration. A few weeks ago a group of industrial and academic research administrators was called together for an informal discussion of the increased military research and development budgets proposed as part of the plan for meeting the threats of a widening war. It was anticipated that this group would consider that the upper limit on what the Department of Defense could spend advantageously for such purposes would be determined by the available numbers of properly trained scientists and engineers, and that the draft and reserve officer policies would be topics of primary concern in the discussion. These topics were actually given considerable weight, but not nearly as much weight as was given to the extent to which our nation, our government, and even our Department of Defense would curtail, postpone, or stop an enormous lot of technical activities which, however desirable, have no high priority bearing on our ability to meet the present emergency. This was posed as the most basic consideration limiting our ability to handle the high priority research and development programs right now.

Most of what I have said this afternoon could have fitted a somewhat different title, such, for example, as "Problems of Leadership and Decision in the National Emergency." However, I have left the title in its original form, "Engineers and National Security," because the background from which my thoughts come is that of administration of scientific and engineering activities, and because engineers are being called upon to an extraordinary degree to deal with situations in which the points which I have discussed are important, and because engineers by their very training and habits of thought are unusually well able to appreciate and to deal with the types of problems which have been outlined here.

RECAPITULATION

IN CONCLUSION, let me recapitulate some of the things I have tried to present for your consideration. Leadership at the higher levels of responsibility is difficult to find in adequate supply. Its identification is a matter for personal judgment and not for formal specifications or rosters. It can be discovered through acquaintances formed in professional associations and through team-work in good causes. It can be developed and discovered in the younger groups by giving them responsibility, and one of the effective ways for the older generation to build up our national technological strength is to pass the responsibilities on to the younger generation as fast as they can shoulder them. Our complex life is so rich in good objectives that there are very difficult conflicts of legitimate interest when a man or an organization is asked to take on a new job for the national security, and the decision for the new job may only be compelling when the emergency becomes very serious.

As engineers, whose professional job and pride is to get things done, these problems and situations pose challenges which the engineering mind is well adapted to tackle effectively.

I am grateful for the honor of the Hoover Medal. I am appreciative of your patience as I have outlined a few of the thoughts which have been running through my mind as I have seen some of the efforts to increase our national security through work of the type which scientists and engineers are uniquely qualified to handle. I am proud to be, even by adoption, a member of the American Institute of Electrical Engineers, whose members play so important a role in our peacetime economy and in our security against disastrous aggression.

New Microfilm Recorder Controlled Electrically

A new microfilm recorder has been designed by Bell and Howell Company, Chicago, Ill., which photographs on 16-millimeter film important papers which are needed for records. The recorder automatically takes care of lens opening and shutter speed. Lighting and film rating are perfect, so the operator does not need to worry about them. Keeping the electricity under control is handled by a device made by the Sola Electric Company, also of Chicago.

Key to the success of the apparatus is synchronizing the camera's shutter action with the movement of items to be photographed. This is handled electrically. The system has three elements which must be in perfect co-ordination. They are: the motor, which revolves a roller over which the documents pass; a light which illuminates the items being photographed; and an electric clutch, which synchronizes camera speed with the speed of the documents passing through the recorder, and insures that each one is opposite the lens at the moment it is photographed.

Because voltage entering the machine is subject to irregularities, a constant-voltage transformer designed and produced by Sola has been built into the set so that variations of line voltage between 95 and 130 volts have no effect on the equipment's operation.

The microfilm recorder is incorporated in a desk (shown at left) with the automatic camera attached to one side. The operator places a pile of papers in the automatic feed, sets a few switches, and the recorder takes over. The papers pass over the spinning roller and drop into a container below. When they are opposite the camera, it takes simultaneous pictures of each side, using a pair of mirrors.

Photos are taken on a 100-foot roll of 16-millimeter film. Front and back pictures of 400 checks can be taken in one minute. The recorder can photograph paper up to 9^1/ inches wide with the automatic feed, and 11 inches with hand feed. Pictures can be scanned later with an illuminated viewer, which enlarges them up to life size.

Vannevar Bush—John Fritz Medalist for 1951

Vannevar Bush

Electrical Engineer, Executive

EVERETT S. LEE
PAST PRESIDENT AIEE

VANNEVAR BUSH, electrical engineer, executive, was born at Everett, Mass., March 11, 1890, son . of Richard Perry and Emma Linwood (Paine) ush, grandson of Richard Perry and Mary Willis (Wilams) Bush, great-grandson of William and Jemina (Perry) ush, and great-great-grandson of William and Dessiah yder) Bush, of Provincetown, Mass. His father was a niversalist clergyman. Doctor Bush was graduated from ufts College with the degree of Bachelor of Science and aster of Science in 1913 nd later took graduate work t Harvard and the Massahusetts Institute of Techology (MIT), both of which warded him the Doctor of ngineering degree in 1916. He was with the test deartment of the General lectric Company in 1913 nd the inspection departent of the United States avy in 1914, instructor in athematics at Tufts Colge in 1914–15, and assistant rofessor of electrical engineering there in 1916–17. hile the United States was engaged in the First World ar he carried on research work in connection with subarine detection for a special board of the United States avy. In 1919 he returned to MIT as associate professor electric power transmission and was made professor in at field in 1923, becoming Vice-President of the Initute and Dean of its school of engineering in 1932. e held these positions until 1938 when he was elected resident of the Carnegie Institution of Washington, D. C., e of the outstanding scientific research organizations the United States.

Vannevar Bush, President of the Carnegie Institution of Washington, was awarded the John Fritz Medal for 1951 "for outstanding contributions to his country and to his fellow men." The medal is awarded annually by the four national engineering societies: AIEE, The American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Society of Civil Engineers, for notable scientific or industrial achievements, regardless of nationality or sex.

GOVERNMENT SERVICE

DOCTOR BUSH brought to his new task the skill of a trained investigator and the experience of a competent leader nd executive. His attention was at once occupied with tension of activities resulting in closer co-ordination of e Institution's research program and more effective co-eration with other educational and research agencies. efinite progress in this direction had been attained by the time of the outbreak of the Second World War, and in 1940, while still retaining his position with the Carnegie Institution, he was appointed by the President of the United States as Chairman of the National Defense Research Committee, a governmental agency established for the purpose of supplementing the work of the Army and Navy in development of devices and instrumentalities of war. A year later Doctor Bush was made Director of the newly established Office of Scientific Research and Development (OSRD) charged with the duty of mobilizing the scientific effort of the country, of initiating in co-operation with the Army and Navy broad programs of research where needed, of advising the President as to the status of scientific research and development in their relation to defense, and of continuing research on instrumentalities and materials of war and in the field of medicine. He continued in this post until the OSRD concluded its activities in December 1947. The National Defense Research Committee (NDRC) and a newly formed Committee on Medical Research constituted the two major divisions of the Office. Various other scientific agencies of the Government, notably the National Advisory Committee for Aeronautics—of which Doctor Bush was a member to 1948, serving as chairman in 1939–41—as well as the National Academy of Sciences, the National Research Council, and research laboratories of educational and industrial organizations throughout the country worked in close collaboration with the OSRD from its inception.

In his capacity first as chairman of the NDRC and then as Director of OSRD, Doctor Bush was a central figure in the development of nuclear fission culminating in the utilization of atomic bombs to bring the war to an end. His official connection with the project began in June 1940, when the earlier constituted Uranium Committee was made a subcommittee of the newly created NDRC. Decision for an all-out effort in the undertaking was reached after the research had progressed satisfactorily and various administrative reorganizations had been made, so that the difficult question of allocating men and materials in a period of national emergency could soundly be answered. Interestingly, the decision was announced to those concerned on December 6, 1941. Doctor Bush, as a member

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Full texts of the presentation and acceptance addresses given at the John Fritz Medal ceremonies held during the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951.

Everett S. Lee is executive engineer, General Engineering and Consulting Laboratory, General Electric Company, Schenectady, N. Y.

of the Top Policy Group headed by the President and as Chairman of the Military Policy Committee, shared the responsibility for the determination of policy throughout the program, continuing in this work after the task of administration and development had been taken over by the Army in 1943.

President Roosevelt in the fall of 1944 called on Doctor Bush for recommendations on ways whereby the lessons learned through the OSRD in time of war might be applied in time of peace "for the improvement of the national health, the creation of new enterprises bringing new jobs, and the betterment of the national standard of living." In response to this request, Doctor Bush prepared a report, issued in July 1945, under the title "Science, the Endless Frontier," which drew on studies made by four committees of eminent scientists, engineers, and educators, and made specific proposals for the consolidation and utilization of the scientific skill of the nation for the general good, which were reflected in legislation considered by the Congress. He served as a member of the President's Research Board as well. In July 1946, Doctor Bush was appointed Chairman of the Joint Research and Development Board (JRDB) of the War and Navy Departments to carry out "a strong, unified, integrated, and complete research and development program in the field of national defense." Passage of the National Security Act of 1947 replaced the JRDB with the Research and Development Board of the National Military Establishment; Doctor Bush served from September 1947, to October 15, 1948, as the first chairman of this organization.

Vannevar Bush

ELECTRONIC DEVICES

Doctor Bush has received patents on gaseous-conduction devices and on cathode arrangements and coatings for grid-controlled arcs. His inventive interests have for years been focused on the application of mechanical and electronic means to reducing the burden of computation, calculation, and repetitive routine on man's intelligence. One expression of this desire is the network analyzer which, with staff members of the Department of Electrical Engineering, he developed at MIT in the late 1920's. This is an electric network on which can be set up the electrical replica in miniature of large and important electric power systems, for the purpose of investigating their performance under stress.

Another and more important result of Doctor Busl interest in apparatus to free man's intelligence for creati effort is the differential analyzer, construction of whi began under his direction at MIT in 1935, and which is radically different and improved advance over the fi machine of the sort, which he developed there in collabor tion with the electrical engineering staff in 1930. T new machine, weighing 100 tons, combined some 2,0 electronic tubes, several thousand relays, about 150 moto and nearly 200 miles of wire to provide solutions of t differential equations expressing mathematical problei involving as many as 18 va ables. Problems in atom physics, acoustics, ballisti structures, and electric m chine transients are repi sentative of the tasks f which the analyzer is d signed.

Other devices such as t rapid selector which sca and selects wanted ite from microfilm, and t justifying typewriter whi produces typescript with a even right-hand margin one operation, have result from Doctor Bush's inventi interest in making machin do more of the pseudo-intel gent work of the world. the *Atlantic Monthly* for Ju 1945, he wrote speculative and fancifully of a hypothe cal machine called t "memex," which, utilizi components of this so would serve as an extensi of man's memory, bringi wanted items before him on viewing screen by means of an associative index, and p mitting him to review at the touch of a finger all his acc mulation of data on a desired subject.

AUTHORSHIP

Doctor Bush is the author of "Operational Circ Analysis" (1929) and many technical articles, and t coauthor, with William Henry Timbie, of "Principles Electrical Engineering" (1922). A collection of his pap and addresses was issued in 1946 under the title "Endl Horizons," with a foreword by the late Frank B. Jewe Doctor Bush's most widely known publication is "Mode Arms and Free Men," published November 21, 1949 discussion of the role of science in preserving democra institutions, which was the Book of the Month Club sel tion for December 1949.

MEDAL AWARDS

Doctor Bush was awarded the Louis Edward L Medal by the Franklin Institute in 1928 for his w on analyzing devices and the Lamme Medal in 1935

: American Institute of Electrical Engineers for "his
velopment of methods and devices for application of
ithematical analysis to problems of electrical engi-
ering." He also was granted the Research Corporation
ard made by Columbia University in 1939, and the Bal-
ı Medal by Tufts College in 1941. The Holley Medal
The American Society of Mechanical Engineers was
arded him in 1943, as well as the Edison Medal "for his
ntribution to the advancement of electrical engineering,
rticularly through the development of new applications
mathematics to engineering problems, and for his
ninent service to the nation in guiding the war research
ogram."

In 1945 Doctor Bush received the Gold Medal of the
itional Institute of Social Sciences for distinguished serv-
: to humanity, the Roosevelt Memorial Association's
stinguished Service Medal, and the Marcellus Hartley
blic Welfare Medal of the National Academy of Sciences.
ie Washington Award was presented to him in 1946 by
: Western Society of Engineers "for outstanding leader-
p in organizing and directing the scientific resources of
: nation toward victory in World War II." In January
47, the Hoover Medal for 1946 was awarded by the
nerican Institute of Electrical Engineers, the American
ciety of Civil Engineers, the American Institute of
ining and Metallurgical Engineers, and The American
ciety of Mechanical Engineers to him as an "engineer,
ucator, and administrator, who, in critical time of need,
s in a most special sense an organizer, guiding spirit,
d driving force of the nation's achievements in physical
d medical science." The Distinguished Service Medal of
fts College came to Doctor Bush in June 1947. On
bruary 11, 1948, he was made Knight Commander of
: civilian division of the Most Excellent Order of the
tish Empire, and on May 27 of that year he received
: Medal for Merit with bronze oak leaf cluster from
esident Truman in ceremonies at the White House.
e medal of the Industrial Research Institute, Inc., was
esented to him in February 1949. With the presentation
the John Fritz Medal in 1951 "for outstanding scientific
ntributions to his country and to his fellow men," Doctor
nnevar Bush becomes the first man in history to receive
se five medals: the Lamme Medal, the Edison Medal,
: Hoover Medal, the Washington Award, and the John
tz Medal.

HONORARY DEGREES AND AFFILIATIONS

: 1932 Doctor Bush received an honorary Doctor of
Science degree from Tufts College and since then he
: also received honorary degrees from Brown University,
ddlebury College, The Johns Hopkins University, the
iversity of Pennsylvania, Yale University, Polytechnic
titute of Brooklyn, Stevens Institute of Technology,
lliams College, Rutgers College, Washington University,
rvard University, Trinity College, the University of
ffalo, West Virginia University, Columbia University,
nceton University, the Carnegie Institute of Tech-
ogy, and Cambridge University. Honorary member-
p in the Franklin Institute was conferred upon him
uary 15, 1947. Long a Fellow of the American Institute of Electrical Engineers, Doctor Bush was inducted as Honorary Member on January 30, 1950, on which day he received Eminent Membership in the honorary electrical engineering society Eta Kappa Nu. He is a fellow of the American Physical Society, and is a member of the American Mathematical Society, the American Philosophical Society, the American Academy of Arts and Sciences, the National Academy of Sciences, and the American Society for Engineering Education. He is a Trustee of Tufts College, The Johns Hopkins University, the Carnegie Corporation of New York, and the Graphic Arts Foundation, a life member of the Massachusetts Institute of Technology Corporation, and a Regent of the Smithsonian Institution. In January 1947, he became a director of the American Telephone and Telegraph Company, and in November 1949, of Merck and Company. He is a member of Phi Beta Kappa, Tau Beta Pi, Alpha Tau Omega, and Sigma Xi, and of the St. Botolph Club in Boston, the Century Club in New York, and the Cosmos Club in Washington. During 1924–32 Doctor Bush held a commission as lieutenant-commander in the United States Naval Reserve. He was married at Chelsea, Mass., September 5, 1916, to Phoebe Davis, daughter of William Hathaway Davis, a merchant of Chelsea, and has two sons, Richard Davis Bush and John Hathaway Bush.

This Period of Transition

VANNEVAR BUSH
HONORARY MEMBER AIEE

IN THANKING you for the honor which you have bestowed upon me, I wish to emphasize some aspects of the responsibilities and opportunities of the engineering profession in the present emergency. For the men upon whom the John Fritz Medal has been conferred in the past—and in whose company I am happy to find myself—are men who have helped to build the industrial democracy of the present day. Merely to mention a few of their names—Alexander Graham Bell, Thomas Edison, Lord Kelvin, Elihu Thomson, General Goethals, Charles Kettering—is to call forth the achievements by which they have given us not only a more efficient world but, as we fully believe, a better world. I am deeply appreciative of the honor of being counted worthy to be included as one of their number.

Occasions such as this are part of the symbolism by which the professional spirit is nourished. To engineers the stimulation of professional consciousness is especially important, for the engineering profession in the United States has not enjoyed the same clearly defined status as has been accorded the teaching profession, the medical profession, or the legal profession. It has lacked their special languages, and the symbolism which marks their long tradition of dedication to the common good. We have not even continued the continental custom of according

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the engineer the courtesy of calling him daily by his earned title of "Engineer." Yet the engineer is in every sense the builder of the physical aspects of society on which all other modern aspects depend. From ancient times, its cities, bridges, and roads have risen under his hands. He has made transportation swift and secure; he has brought the exotic to our doors and sent the products of our machines to the far corners of the world. He bridges the gap between the dream and the reality and has made our modern world a marvel of speed, precision, and durability.

What could follow more naturally, then, than that engineers should unite in the enunciation of a belief that their mission as a profession lies in intelligent, positive, dedicated ministration to the people?

Eleven years ago, I said something quite similar at a dinner given by the American Engineering Council. Then we were moving rapidly, but we knew not how rapidly, toward world catastrophe. But during that catastrophe we achieved a unanimity and a unity of action that enabled us to overcome the dangers which unpreparedness and shortsightedness had forced upon us. Five years ago we cherished a brief hope that we had emerged from the period of destruction and stress and could set ourselves wholly to the task of rebuilding. We hurriedly and ill-advisedly discarded not only the paraphernalia of war but most of the disciplines and armament which would have enabled us to rebuild on a more secure foundation.

John Fritz Medalists

Lord Kelvin	1905
George Westinghouse	1906
Alexander Graham Bell	1907
Thomas A. Edison	1908
Charles T. Porter	1909
Alfred Noble	1910
Sir William Henry White	1911
Robert Wollston Hunt	1912
John E. Sweet	1914
James Douglas	1915
Elihu Thomson	1916
Henry Marion Howe	1917
J. Waldo Smith	1918
George W. Goethals	1919
Orville Wright	1920
Sir Robert Hadfield	1921
Eugene Schneider	1922
Guglielmo Marconi	1923
Ambrose Swasey	1924
John F. Stevens	1925
Edward D. Adams	1926
Elmer A. Sperry	1927
John J. Carty	1928
Herbert Hoover	1929
Ralph Modjeski	1930
Admiral David W. Taylor	1931
Michael I. Pupin	1932
Daniel C. Jackling	1933
John Ripley Freeman	1934
Frank J. Sprague	1935
W. F. Durand	1936
Arthur N. Talbot	1937
Paul D. Merica	1938
Frank B. Jewett	1939
C. F. Hirshfeld	1940
Ralph Budd	1941
Everette DeGolyer	1942
Willis Rodney Whitney	1943
Charles Franklin Kettering	1944
John L. Savage	1945
Zay Jeffries	1946
L. W. Chubb	1947
Theodore von Karman	1948
Charles M. Allen	1949
Walter Hull Aldridge	1950
Vannevar Bush	1951

NEW TIME OF PERIL

NOW WE FIND ourselves in a new time of peril which is all the greater because the danger is unconventional and unpredictable. The Fascist Axis was a formidable threat to the free world but it was concentrated and it was specific. The threat which hangs over us today is amorphous and uncertain, not susceptible to the old rules
diplomacy and negotiation by which nations adjusted th
differences. We know we are faced with a great dang
but do not know what forms it may take, where we w
have to grapple with it next, nor how long we may
harassed by threats which try our souls. We have r
tested our capabilities for discipline, self-sacrifice, a
denial in a period which lacks the unifying stimulus
open warfare. It may lead us to absurd extremes,
unnecessary sacrifice of our liberties, to improvidence a
inflation, but on the other hand it may refine our dem
cratic system and render it more stable as we unite und
stress.

In such a situation, real responsibility devolves up
organized groups of citizens to take the initiative in worki
for intelligent measures which will help overcome t
present dangers with the minimum damage to our affai
The self-discipline and sense of order which arise natura
out of long association in an efficient organization can
effectively applied in national affairs to the sensible marsha
ing of defenses and the forestalling of panic or indecisio
The engineering profession, with its devotion to clarity a
precision of thinking about practical affairs, has here spec
opportunity and special responsibility.

The war in Korea, which for the dead and the maim
is just as conclusive as any in history, may save us if
are able to profit from the lessons it has taught.

UNIVERSAL MILITARY TRAINING

IT IS EVIDENT, for example, that we need a large reserv
of trained military man power which can be broug
into being only by universal military service. It is equa
apparent that to man power we must add greater fire pow
to offset the numerical superiority which we know we m
face. It is not quite so evident, but equally importa
that this fire power must be modern in every sense of t
word, that we cannot meet hordes man for man, that
must have superior weapons and avoid spending v
sums on the obsolescent.

It used to be one of our national characteristics to belie
that there will always be plenty of time. Perhaps we a
now shaking this fallacy off. Three-and-a-half years a
the President's Advisory Commission on Universal Traini
submitted a vigorous report in which the Committee re
ommended universal military training in these words:

"After nearly six months of the most intensive study, t
members of this Commission have arrived at the unanimo
conclusion that universal training is an essential eleme
in an integrated program of national security intended
safeguard the United States and to enable us to fulfill o
responsibilities to the cause of world peace and the succ
of the United Nations. . .

"We recommend the adoption of universal training b
cause we are convinced that weakness on our part not o
involves our country in grave risks but also weakens t
United Nations, on which rest our hopes for lasting pea
A weak and irresolute America is an invitation to failu
A strong and resolute America is the best guarantee for o
safety and for the success of the United Nations."

In the absence of a sufficiently strong body of pub inion for the realization of the Committee's recomendations, its report slowly gathered dust in the limbo of glected documents. Now that our national peril has rced the issue squarely upon us, our position is worsened the time that has been irrevocably lost. Ironically, any signatories to the report, among them Charles E. ilson, Karl T. Compton, and Anna M. Rosenberg, ain labor in Washington to help pull us out of our present edicament. Had their sound advice been heeded when was first given, we would find ourselves in a more favorle position today.

What they proposed was modest enough: six months of sic training to be followed by optional choices of service the National Guard, the Organized Reserve Corps, the nlisted Reserve Corps, or some combination of these ith further educational training. Men who had disarged their obligations would return to civilian life with great disruption of their lives.

UNIVERSAL MILITARY SERVICE

NOW THE WORLD situation has forced upon us far more stringent requirements. We now need a strong miliry force in being, and we have lost precious time. Toay's planning is not in terms of universal military training ut of universal military service. The Congress is presntly considering legislation under which all males reachg the age of 18 will be faced with 27 months of training id service, to be followed by a term of enlistment in the eserves or the National Guard. Tests will be adjusted use nearly the entire group in appropriate manner, not erely those who qualify physically for the rigors of combat. few will be assigned to special training in the colleges, preparation to become officers or for other special rvice, but under controls which will insist that they also nder service when and as ordered to do so. I trust that plans mature, women also will be used for the many nctions they can perform exceedingly well.

A long-term, continuing program of this type is now the ly means by which we can establish promptly an adeate force and maintain it for as long a time as the world uation requires that we have armed forces of millions of en.

As this country turns to universal military service, as we luctantly take this serious step in our national affairs, it well to remember that training often spells the difference tween life and death in combat. On many a battleld the trained live and the untrained die. We do not ow when or where we may be called upon to fight again preserve our liberties, to preserve our very existence. ur one chance to do so without total war is to be ready it in every possible way.

The recent superb operation in which the First Marine vision and the Seventh and Third Infantry Divisions ght their way to the sea shows us what courage linked to ining and discipline can do in the face of almost imssible conditions. The evacuation of Hungnam, which complished the removal of 105,000 troops, 91,000 ilians, and 235,000 tons of supplies, deserves to rank th the great military actions of our time. Americans far more stirred by defeats than by success. They would do well to remember the wise words of Montaigne, who said: "There are some defeats more triumphant than victory." We have taken a defeat in Korea; we are now roused. The world knows that when we are really aroused we act. We will act this time, but it must be with clear deliberation and for the long pull.

PREPAREDNESS

OUR PEOPLE have had no experience in war on their own soil. Our citizens at home had none of the bitter lessons through which people of other nations learned to survive all-out war. If total war should break out soon, it might open with a surprise attack on this country. I do not think this is imminent, but we must be ready for surprise attack if and when it comes. We are by no means ready now, and it will take time to prepare. We are threatened not only with conventional war but with unconventional means of subversion and disruption. Our enemy may not stoop to some of the more appalling forms, but it may, and we must be ready. The presence of trained and disciplined citizens in every community is necessary to avoid panic and to make possible the swift and proper action which is necessary to cope with the methods and weapons of modern warfare.

The man power situation will be acute in the armed forces and elsewhere. With Congress putting many added billions of dollars into defense, there will be a number of conflicting demands for engineers as well as for other professional men. The Services now are giving serious thought, for example, to the problem of calling up engineers who are in reserve status. The need of the armed forces for engineers is important right now, but if they are called up in too great numbers, we are in some danger of wrecking the industry we are trying to put back on a war production basis. This is just one problem among very many.

PART ENGINEERS CAN PLAY

WE CANNOT expect to be both comfortable and happy in the immediate future. We shall have to strip ourselves of excess fat and gird ourselves for a long fight whether it be a hot war or the present war of attrition. Engineers have always constituted a stable and constructive element in our society. Theirs is a profession founded on the concept of ministration to the people. Theirs is a discipline devoted above all to practical rigorous thinking and planning. Who, better than they, could take the initiative in suggesting that it is better to sacrifice a few of the external niceties of our own way of life now in order that we may be sure of passing it on intact to those who come after us?

Who, better than they, to get in and work, to solve some of the dozens of problems we face nationally in this period of transition in our national life? There are opportunities all about for those with the professional and administrative skill, and the willingness to undertake sometimes disagreeable jobs. On the way in which we meet the present emergency, on the wisdom which is brought to bear, on the devotion of our citizens everywhere, will depend the way in which we and our children live our lives for a generation to come.

Standards for Electrical Measuremen

F. B. SILSBEE
FELLOW AIEE

PRECISE electrical measurements are of fundamental importance to modern science and industry. This is true not only in the communication and power fields but in many other areas where the flexibility and convenience of electrical methods have made them almost indispensable for the measurement of nonelectrical quantities. Thus, while in textbooks energy is defined simply in terms of force and length or of mass and velocity, in actual practice the heat energy of fuels and the energy output of prime movers are universally measured with high precision by electrical methods. Likewise, the basic electrical units enter into the determination of nearly all the fundamental atomic constants, as well as into daily measurements of heat, light, color, strain, acceleration, displacement, and chemical properties.

Effective application of electrical equipment and measurement methods requires uniformity to a high degree of precision in the basic electrical units. Some $2,000,000,000 worth of electric machinery and apparatus is manufactured annually in this country. Were each manufacturing company to use an even slightly different value for the volt or the ohm, the apparatus made by its subcontractors would fail to function properly as a part of the final product. The result would be an impossibly confused situation, causing large financial losses everywhere in the nation. In the communications industry, the multiplex transmission of intelligence over a relatively small number of circuits is dependent on the precise adjustment of capacitance, inductance, and other circuit components in such a way that signals are prevented from straying into the wrong channels. Again, this requires precise uniformity in the measurement of the basic electrical units.

At the National Bureau of Standards most precise methods are used for measuring and determining exact values of electrical units. The testing and calibration work of the Bureau is available for an appropriate fee to anyone who needs this high-accuracy service.

As the custodian of the national standards of physical measurement, the National Bureau of Standards has the responsibility of insuring that the units of measurement used in science and industry are constant through the years and uniform throughout the nation. The Bureau has developed very precise standards of resistance and voltage whose values are established by absolute measurements that fix the relation between the electrical units and the fundamental mechanical units of length, mass, and time.[1] From these basic absolute electrical standards, the Bureau has derived other standards for all electrical quantities in use today.

Because of their technical difficulty, precise absolute measurements are carried out only in the national stan ardizing laboratories of a few of the larger countries. Suf cient accuracy in science and industry is obtained throu accurate comparison of the secondary or working standar of other laboratories with primary standards thus calibrate In this country such comparisons constitute the Bureau calibration service. Each year about 2,000 high-grad electric instruments, standard cells, and other measuri apparatus go through the Bureau's electrical laboratori The services performed range from the comparative simple measurement of the electromotive force of a standa cell to the determination of the ratio and phase angle of multirange current transformer at several frequencie currents, and loads, which may require 1,000 separa measurements. Among the devices submitted are standa resistors, potentiometers, bridges, resistance boxes, vo boxes, capacitors, inductors, multimegohm resistors, instr ments and meters of all kind precision shunts for large cu rents, instrument transform ers, standard magnetic te bars, magnetic test coils, an standard cells of both th saturated and unsaturat types. They come from manu facturers of electric equi ment, from public utility com panies wishing to make sure that their charges are correc from public service commissions which regulate the utili companies, and from communication laboratories, unive sity laboratories, private commercial testing laboratori and the many scientific laboratories operated by the Feder Government.

The demands of modern science and technology ha made this work more and more exacting, not only as regar accuracy but also in the range of values and variety of uni in which measurements are made. Thus the Bureau no measures precisely currents, voltages, and resistances havi values up to tens of thousands of amperes, hundreds thousands of volts, and millions of billions of ohms respe tively. This is done with direct current, with alternati current of various frequencies up to thousands of meg cycles per second, and with surges of current lasting only few millionths of a second.

ESTABLISHMENT OF UNITS

THE BASIS of the Bureau's standardization of electric mea urements is the establishment of values for the oh and the ampere that bear the desired simple theoreti relation to the meter, the kilogram, and the second. Ho ever, since an electric current is by its nature evanesce the volt, derived from the absolute ampere at the time t

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Full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 22-26, 1951.

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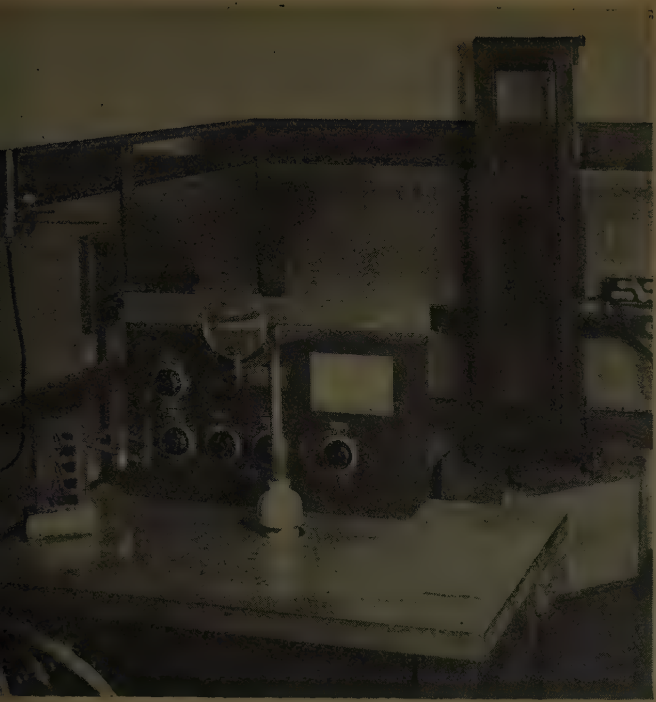
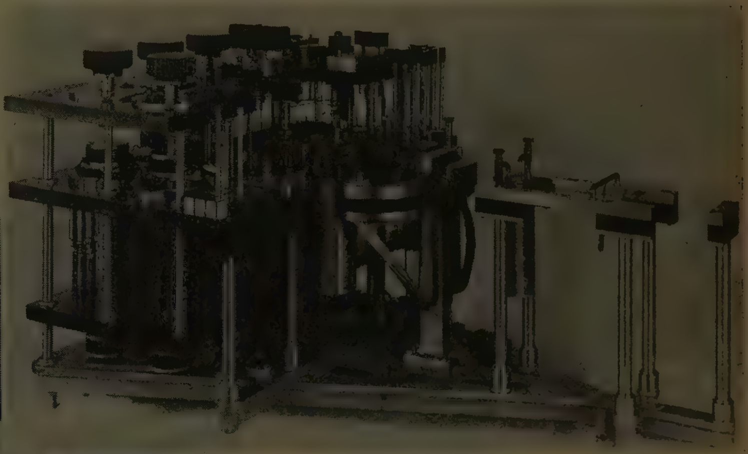


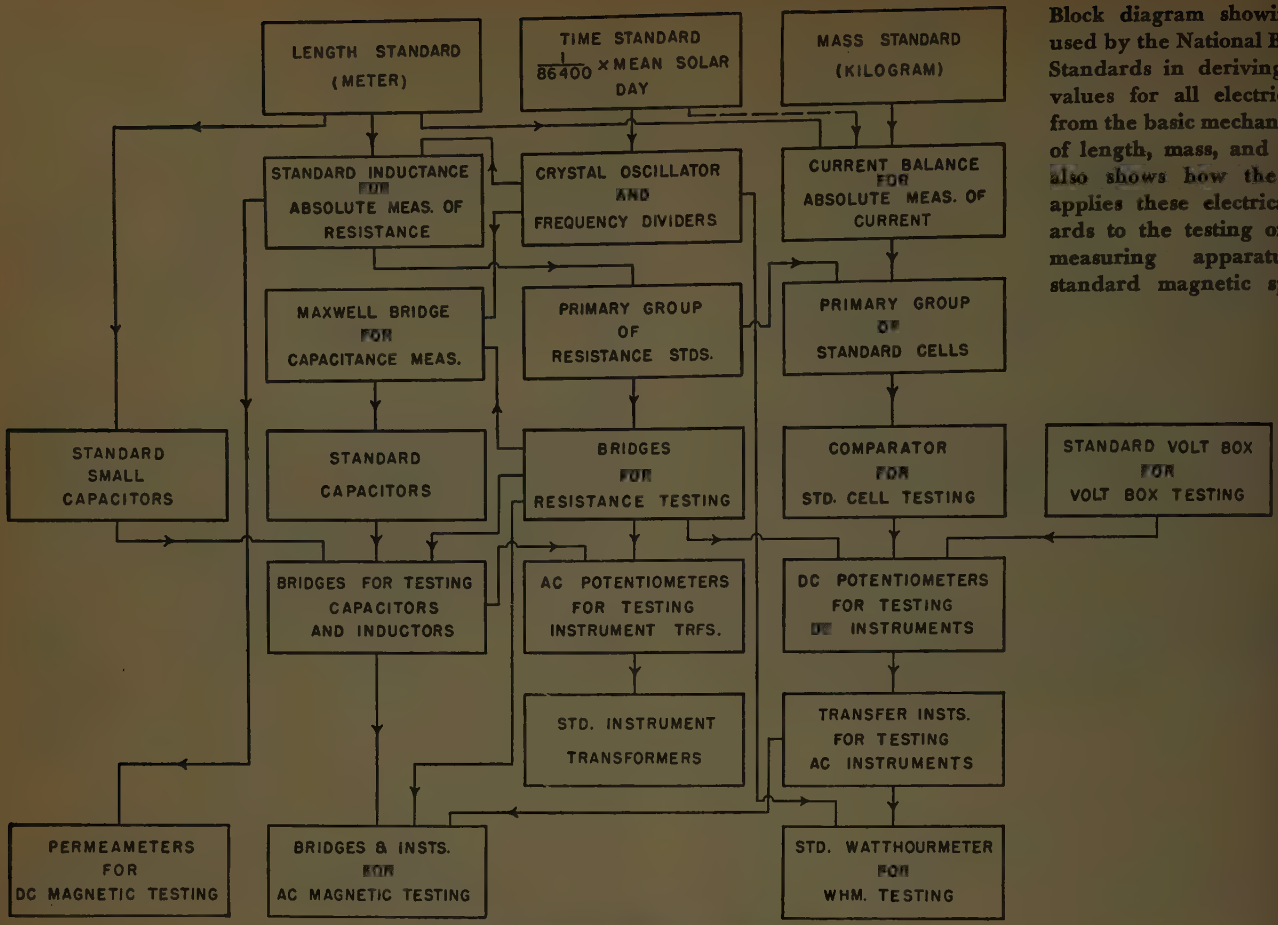
andard astatic wattmeter (right background) used to make the ansfer from the d-c standard cell and resistors to a-c measure-ents of voltage, current, and power. The wattmeter is cali-rated by observing its deflection for a definite amount of d-c ower, then measuring a-c power. Rotation of the movable ils in the center of the frame deflects the mirror just above them that a reflected light beam moves along the scale in the fore-round. Use of two movable coils serves to balance out effects due to the earth's magnetic field

Coils of the current balance used at the National Bureau of Standards to "weigh" current for the absolute determination of the ampere. The smaller coil is suspended, coaxially with the two larger coils, from the pan of a sensitive balance. When a current flows through all three coils in series, the mechanical force between the small and the large coils is measured with the balance. From the value of this force and the mechanical dimensions of the coils, the absolute value of the ampere is computed by the scientists at the Bureau

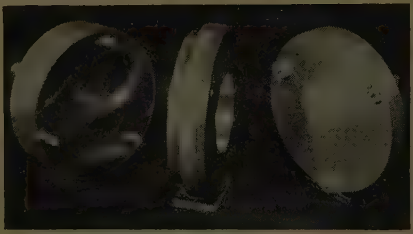
Calibration of a Mueller bridge in a laboratory the National Bureau of Standards. If the in-rument is calibrated frequently, it can measure sistance with an accuracy of a few parts in a illion. A second bridge, to the left of the one nder test, is used to adjust the external resistance connected to the first bridge



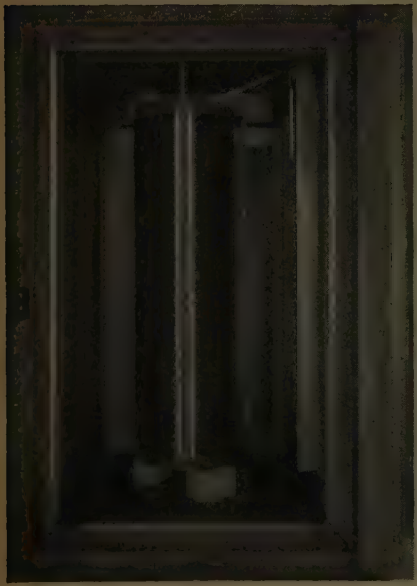
▲ High-precision d-c bridge used to extend scale of measurement of electrical resistance from standard units to other ranges. By successive application of the 10-to-1 ratio which the bridge provides, resistances as low as 0.00001 ohm or as high as 10,000,000 ohms can be measured accurately. In use, the whole structure is immersed in a temperature-controlled oil bath to a level above that of the intermediate insulating slab so that all resistors and contacts are kept at a uniform temperature. The instrument may be connected either as a Wheatstone or as a Kelvin double bridge


LENGTH STANDARD (METER)
TIME STANDARD 1/86400 × MEAN SOLAR DAY
MASS STANDARD (KILOGRAM)
STANDARD INDUCTANCE FOR ABSOLUTE MEAS. OF RESISTANCE
CRYSTAL OSCILLATOR AND FREQUENCY DIVIDERS
CURRENT BALANCE FOR ABSOLUTE MEAS. OF CURRENT
MAXWELL BRIDGE FOR CAPACITANCE MEAS.
PRIMARY GROUP OF RESISTANCE STDS.
PRIMARY GROUP OF STANDARD CELLS
STANDARD SMALL CAPACITORS
STANDARD CAPACITORS
BRIDGES FOR RESISTANCE TESTING
COMPARATOR FOR STD. CELL TESTING
STANDARD VOLT BOX FOR VOLT BOX TESTING
BRIDGES FOR TESTING CAPACITORS AND INDUCTORS
AC POTENTIOMETERS FOR TESTING INSTRUMENT TRFS.
DC POTENTIOMETERS FOR TESTING DC INSTRUMENTS
STD. INSTRUMENT TRANSFORMERS
TRANSFER INSTS. FOR TESTING AC INSTRUMENTS
PERMEAMETERS FOR DC MAGNETIC TESTING
BRIDGES & INSTS. FOR AC MAGNETIC TESTING
STD. WATTHOURMETER FOR WHM. TESTING

Block diagram showing ste used by the National Bureau Standards in deriving preci values for all electrical uni from the basic mechanical uni of length, mass, and time. also shows how the Burea applies these electrical stan ards to the testing of electr measuring apparatus an standard magnetic specime



A type of "guard-well" capacitor designed provide primary standards of extremely sma capacitance—from 0.1 to 0.001 micromicr farad. By increasing the thickness of the ri shown in the center, the measured capacitan may be decreased to values as low as desire



Construction of this self-inductor, whose inductance can be computed accurately from its dimensions, has permitted determination of the ohm to an accuracy of a few parts in a million. The 1,000 turns of the coil are wound in a lapped helical groove on a Pyrex glass form about 35 centimeters in diameter and 1 meter long. The diameter and average pitch of the coil have been measured to one part in a million. Its inductance is 103 millihenrys

All types of ammeters, voltmeters, wattmeters, and other electric indicating instr ments are tested in this laboratory at the National Bureau of Standards. The o server at the right is adjusting a potentiometer which is being used to check t calibration of a d-c instrument. The observer at the left is setting the desired i dication on the instrument under test.

tter is measured, is embodied in the calibration of a oup of standard cells which, together with the standard sistors embodying the ohm, are kept as permanent priary standards.

The determination of the ohm consists of two steps. The st is the construction of an inductor (either self- or mutual) hich is so designed that its essential dimensions can be easured mechanically with high accuracy and which is of ich a shape that the inductance can be calculated from ese measured dimensions. Both self- and mutual inducrs have been prepared at the Bureau by winding wire in pped helical grooves on forms of glass, quartz, or porcelain. he second part of the process consists of an electrical periment in which a bridge or equivalent circuit is used compare the reactance of the inductor at a known freiency with the resistance to be measured. When the sistance in absolute ohms of the resistors used in the bridge rcuit has been determined in this way, the absolute resistice of other standard resistors can be found by comparison ith the resistors in the bridge.

A current is measured in absolute amperes by determing the mechanical force between two parts of the circuit in hich it flows. In the center of two large fixed coils a nall coil is hung from the arm of a precision balance. All ree coils carry the current to be measured, but the curnt in the fixed coils can be reversed. The small electroagnetic force developed by the current in the coils tends pull the movable coil downward for one direction of the irrent in the fixed coils but tends to lift it when this current reversed. From the change in the force on the balance hen the current is reversed and from the measured dimenons of the coils, the value of the current in absolute amperes n be computed.

A second feature of this experiment makes use of the ndard current while it is being "weighed" to measure rectly the electromotive force of a standard cell in absolute lts. This is done by arranging the standard cell so that electromotive force is exactly balanced by the drop of tential produced in a known resistance by the standard rrent. The electromotive force of the cell then is comted by Ohm's Law.

A group of 25 standard cells and a group of ten carefully nstructed 1-ohm standard resistors serve to preserve the lues of the volt and of the ohm from day to day and from onth to month. The various members of each group of ndards are intercompared at intervals of a few months, d as long as their relative values are constant it is assumed at the absolute mean value of the group has remained connt also. If an individual standard is found to have ifted relative to the others in its group by a significant hount since the previous intercomparison, it is rejected d replaced by another standard which has a good record performance. The process of comparing a resistor with standard mutual inductor is so convenient that it is freently used as an independent check on the constancy of group of standard resistors. However, the mechanical asurement of the dimensions of the inductors and of the rrent balance is so tedious and time-consuming that this perimental work is carried through only once in a decade the final check on the constancy of both types of standard.

From the standard ohm and volt thus maintained at the Bureau, the other electrical and magnetic units are derived by a variety of experimental procedures. The farad is obtained precisely by charging and discharging an air capacitor at a known rate in a Maxwell commutator bridge. The henry is determined by comparison with capacitors and resistors in a Maxwell-Wien bridge. The ampere is reestablished, when desired, by measuring with a potentiometer the drop it produces in a known resistance. The ampere and the volt are combined to give the watt, and the joule and kilowatt-hour are derived by maintaining a known number of watts in a circuit for a measured length of time. The gilbert and the oersted are computed from the number of ampere-turns used in magnetizing a magnetic test specimen in a permeameter of known geometry. The gauss and maxwell are obtained from the deflections of a ballistic galvanometer which, in turn, is calibrated by reversing a measured current in a known mutual inductor.

EXTENSION OF RANGES

THE EXTENSION of the scale of measurement of any of the electrical quantities to other ranges is based, in large part, upon the establishment of a 10-to-1 ratio in a special, highly accurate bridge. By successive applications of the ratio, resistances as low as 0.00001 ohm or as high as 10,000,000 ohms can be measured accurately. Still higher resistances up to 10^{15} ohms are measured by more complex methods, such as the determination of the rate of accumulation of charge in a known capacitor. Inductance and capacitance measurements are extended over wide ranges by means of ratio arms of known resistance ratios. However, determinations of standard capacitances below one micromicrofarad are based upon an independent set of measurements involving the construction of air capacitors of such shapes that their capacitance can be computed precisely from their dimensions.

Direct currents as high as 10,000 amperes are measured with a potentiometer and standard resistors of low value so constructed that their temperature and resistance are not affected by the very considerable heat developed when large currents are used in them. Direct voltages up to 1,500 volts are measured by means of potential dividers or volt boxes. The ratios of the dividers are derived by connecting in series groups of resistors whose relative individual values have been found by substitution methods. Specially constructed resistors, shielded to avoid corona discharge, are used in X-ray testing to measure direct potentials as high as 1,400,000 volts. In the upper part of this range additional shields separately maintained at appropriate intermediate potentials are required.

The great bulk of the electric energy generated and utilized throughout the country is distributed as alternating current. The step from the d-c standard cell to a-c measurements of voltage, current, and power is therefore of fundamental importance. For 60-cycle work, the transfer is carried out by means of two specially constructed astatic electrodynamic instruments, a wattmeter and a voltmeter. In these instruments the moving coils are supported by taut strip suspensions, and the position of the moving coils is indicated by a spot of light on a scale at a distance equivalent to a pointer 13 feet long. The wattmeter has been carefully compared both with a quadrant electrometer and with the loss in a capacitor which had been tested in a Schering bridge; such measurements have established the accuracy of the two electrodynamic instruments at frequencies up to 3,000 cycles. Directly or indirectly, the accuracy of practically all the a-c instruments used in the transmission of electric energy depends on these two standard instruments. For tests of ammeters and voltmeters at 400 cycles and above, transfer circuits employing thermocouples are used also.

In commercial practice the range of alternating current is extended upward from five amperes by means of calibrated current transformers. Thus, an important part of the Bureau's calibrating service consists in the calibration of standard current transformers which, in turn, are used by manufacturers and electric utility companies to calibrate their working transformers. Special 4-terminal standard resistors, constructed to have negligible skin effect and a known computable inductance (hence a known phase angle), are used to measure the ratio and phase angle of transformers up to 2,500 amperes with a specialized form of a-c potentiometer. Beyond this limit, up to 12,000 amperes, the unknown transformer is compared with a multirange standard transformer, which is calibrated on its lower ranges by the use of standard resistors and then is used as a standard on its higher ranges. Careful study of this standard transformer has given assurance that its various ranges bear simple integral ratios to one another.

Similarly, the extension of the alternating voltage scale above 150 volts is, in practice, based upon the use of voltage transformers. A special shielded resistor, capable of operating at 30,000 volts, is used to measure the effective ratio and phase angle of voltage transformers up to this limit and also to check the performance of standard multirange transformers when they are connected for 25,000 volts. These multirange transformers then can be connected for 50,000 or for 100,000 volts and used as standard at these latter ratings. A still larger standard transforme is calibrated with its coils in parallel at 100,000 volts an used with its coils in series as a standard up to 250,000 volts

Electrical resistance is measured in terms of length, time, and the permeability of free space by both the mutual- and self-inductance methods. In the mutual-inductance, or Wenner, method, a group of reversing commutators, a reversing generator, and an inductor generator must be driven at a constant known rate and with fixed relative phases. The driving equipment is shown at the right, where a Bureau of Standards scientist is adjusting the timing of electronic relays for controlling the speed

For all this testing and calibration work, other than tha performed for the Federal and State governments, the la requires the Bureau to charge an appropriate fee.[2] Thes fees are high enough to avoid subsidized competition wit private testing laboratories but are low enough to make i possible for all industrial laboratories to attain high accuracy where desirable in their work. In any event, th cost to both government and industry of the Bureau's electrical standardization services is slight in comparison wit the savings to the nation which result from the program For example, the electric power industry has now grown t the point where the annual bill for electric energy is approximately $4,000,000,000. If there were a consisten error of 1 per cent in the standards used at the Bureau t calibrate the electric meters with which the industry calibrates its customer meters, either the power companies o the consumers would lose $40,000,000 each year. Yet th cost of maintaining the Bureau's service in this field is muc less than 1 per cent of the discrepancy.

High-voltage equipment. Right, th 2,000,000-volt surg generator. Center 350,000-volt transformers serve as supply for th measuring circui and other 60-cycl tests. The transformer with th smooth tank ha ratings of 125,00 and 250,000 volt

The Bureau is currently making efforts to meet the demand for ever-increasing volume and complexity in electrical standardization work. Techniques are being developed for the more accurate measurement of man-mad lightning—very short duration surges of high current— which are coming to be used by electrical manufacturers t test high-voltage equipment. Methods also are bein worked out for the more rapid and economical checking o watt-hour meters; the testing of the very high resistance now used in measuring ion currents and other radiatio effects; and the testing at 400 and 1,000 cycles per second o those instruments and instrument transformers intended fo use on aircraft and in induction furnaces for heat-treatin of metals.

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Some Engineering Aspects of the Mechanism of Body Control

ROBERT MAYNE

THIS ARTICLE is concerned with an attempt to apply engineering principles to the analysis of the control of body movements. The problem is approached rom a system viewpoint and, of necessity, only very coarse locks will be considered.

It seems desirable at the outset to define the general rea of our proposed investigation. If we are to build up physical model of the mechanism of body control it would ppear reasonable, or indeed necessary, that we exclude onsciousness as a causal factor and that we accept whatver restriction such exclusion may impose upon our field f investigation. A particular set of body movements nay be visualized to originate as a purpose in the nonhysical world of consciousess and to mature into objecive reality through the procss of conditioning of reflexes nd training. At the end of nis process, body movements re believed to be largely inependent of conscious reactions. Picking up a pencil on table, for instance, involves no consciousness except as trigger reaction in the form of a desire to pick it up.

Motions of the body become amenable to the disciplines of control and communication engineering after they have been learned. They are shown to involve presetting, closed-loop operation, and prediction.

We shall be concerned here only with movements after hey have become habituated or mechanized through a rocess of training. We shall try to show that within this mited field there are clear-cut applications of control ngineering. It is hoped that our investigations may find ltimate use in the analysis of the behavior of dynamic ystems of which a human operator is a part, as in the case f a pilot-airplane system.

RESPONSES TO VISUAL INPUT

WE BEGIN our investigation by examining the responses of a human operator to visual inputs.

The process of comparing the input to a human operator ith the output, and applying operational analysis, has een pioneered by a number of experimenters in the eld, including Tustin,[12] Ellson,[2] and Taylor.[8,9] However, tempts to determine a mathematical expression relating ch input and output met with only limited success. aylor,[10] for one, warned against the uncritical use of such ethod and outlined a number of variabilities which are rmally associated with the human operator. It is one the main theses of this paper that no unique expression, transfer function, can represent the human operator, ho is a different mechanism under different conditions.

A very simple setup was used in obtaining the responses used in this paper. Subjects were asked to follow with a pencil a line drawn on the paper of a standard recording instrument. The paper was driven at a fixed speed and the position of the line at any instant could be viewed through a narrow, transverse slot. The original line drawn on the paper represented the input, the line drawn by the subject, the output, and the difference between the position of the two lines at any instant, the error. Various inputs, including step and sinusoidal functions, were used. The results obtained with this simple setup were similar to those obtained by other experimenters, such as Taylor and Ellson, and are believed accurate enough for the general conclusions drawn here.

In passing, it may be noted how easily the subject becomes animated with the purpose to perform the task in question. It is enough to instruct him to perform it. Lest we take this operation too lightly, we need only consider for a moment the difference between two instructions such as "please perform this task" and "perform this task immediately—or else." We would have trouble accounting for such difference in terms of servo theory.

Figure 1 indicates a typical response to a step function. The response may be divided into two parts: a dead portion immediately following the input, lasting approximately 0.26 second; and a dynamic portion representing the actual delayed motion of the hand in response to the input. The dead portion of the response may be identified with the so-called reaction-time delay. In turn, the dynamic portion may be divided in two parts: a fast response which ends at a point somewhat in error of the target position, and a slow drift to this position. The character of the dynamic response changes with the desire

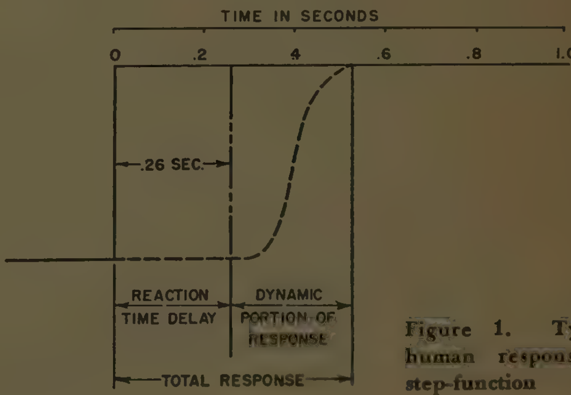

Figure 1. Typical human response to step-function input

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sential text of a conference paper presented at the AIEE Fall General Meeting, klahoma City, Okla., October 23–27, 1950.

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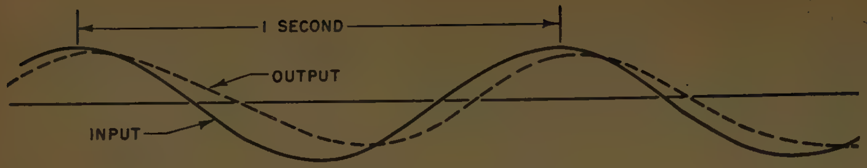
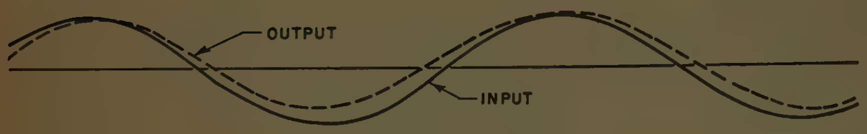


(a.) "CLOSED LOOP" RESPONSE



(b.) "SYNCHRONOUS" RESPONSE

Figure 2. Typical response to simple sinusoid

of the subject for speed and it may become oscillatory.

The responses to sinusoidal inputs may differ widely for the same input. Figure 2 shows a typical response to such an input—a 1-cycle-per-second simple sine curve. At first, the response may be observed to follow the input with a certain phase lag, then, with little transition, to fall into synchronism with the input without phase lag at approximately the right amplitude. Therefore, two modes of responses are possible—one which exhibits a certain phase shift, such as may be normally expected of a closed-loop servo, and one with little or no phase error.

When the simple sinusoidal input exceeds a certain frequency the response becomes confused. If a complex input is presented with high-frequency components, the human operator behaves like a well-designed servo and the output becomes a smoothed-out function of the input.

A need exists for correlation between the responses, more particularly between:

1. The response to a step function with characteristic reaction-time delay.
2. The response to a sinusoidal input with a generally stable phase lag between input and output.
3. The response to a sinusoidal input with no appreciable phase error.

PRESET OR AUTOPILOT TYPE OF RESPONSE

One of the important characteristics of the response to a step function is that it does not depend upon the continuous observation of the input. If the length of the step is indicated on the paper for only a very short time, the response is still carried out as before although there is no line showing the target point of the motion, and the eyes, therefore, can have no part in the control except for a quick observation of the length of the step before the start of the response. It appears that this quick observation is used as the basis of a computation leading to the setting of the required motion in the neural centers. It is easy to find numerous examples of this type of operation in the normal activity of the body. If we lay a pencil in front of us on a table we can pick it up almost as effectively with our eyes closed, following a quick glance at its position, as we can with our eyes open. This type of response has been noted by other investigators,[6,8] but an attempt will be made here to suggest its likely mechanism.

A complex body activity is believed to involve the operation of a system of many closed loops. Some of these loops may be partly outside the body, including senses such as the eyes as error-detecting devices, or they may be totally contained within the body. In the latter case, the inputs to the servos are set intermittently in accordance with computations performed on data collected by external senses such as the eyes. The system may be likened to an aircraft with its autopilot and navigator. Following a set of observations the navigator performs certain computations in determining the course to his desired destination. He then sets this computed course in the autopilot, placing the airplane under internal closed-loop control. The gyroscope and directional instruments then will detect the error between the set and actual courses, or between the set and actual altitude, and will endeavor to reduce this error to zero. A moment later the navigator may make another observation, compute another course, and set it again into the autopilot. This relieves the navigator of routine tasks and leaves him free to perform higher functions.

Similarly, the eyes need to intervene only at discrete intervals into the various closed-loop controls of a complicated body activity, although in some cases they can also operate continuously in these loops. As in the case of the airplane, the information gathered at various intervals is analyzed and necessary computations are carried out. The results of these computations are used to set up inputs in the neural centers for the closed-loop controls which carry out the habituated motion associated with the governing purpose. As in the case of the airplane, an internal space reference is required. This type of response may be said to be of the preset or autopilot type.

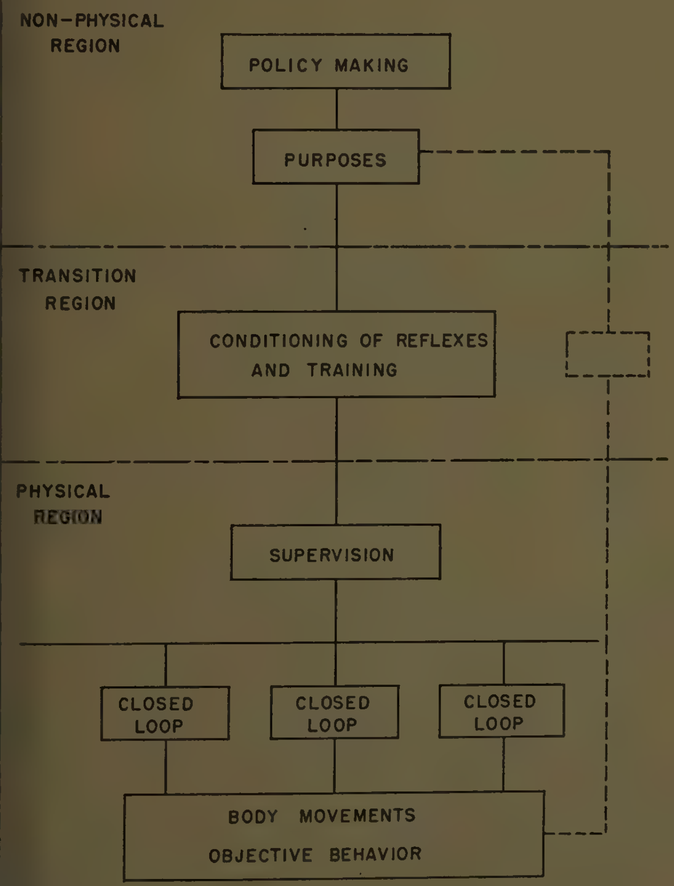
The need for the preset type of control is made evident even by a superficial consideration of a complex body activity. It would be impossible to carry out simultaneously the various movements involved in such an activity under continuous control of the eyes. The load on these senses would be excessive.

In the control of body movements there appears to be a hierarchy of functions (see Figure 3), each with a successively lesser choice in course of actions. There is also a tendency for the responsibility for a particular behavior to be shifted as far as possible to the lowest in rank. At the highest level is consciousness where broad policies are shaped. Then comes the determination of the course of action and strategy best adapted to carry out the policies. Finally the action is carried out by closed-loop systems operating under the specific instructions of a supervisory system including external senses and computing centers. It is these low-level functions which are believed amenable to the discipline of physical science.

NORBERT WIENER[13] had recourse to certain abnormalities in the control of body movements and to laboratory xperiments on the muscles of cats in order to demonstrate he existence of closed-loop operation. Evidence of this hould also be found in normal functioning of the body.

If these responses are carried out in linear closed-loop ontrol, correlation should exist between the responses to tep and sinusoidal inputs: one response should define he other. A transfer function, derived from the step unction, for instance, should predict the phase shift and mplitude ratio of the output with respect to a sinusoidal nput. It can be seen easily that such correlation is not ossible in the case of a sinusoidal response without phase ag. A linear closed-loop mechanism capable of responding n this manner would give an instantaneous change in osition in the case of step input. This is both impossible nd contrary to observed facts. We may, therefore, ismiss this mode of response in so far as correlation etween step and sinusoidal input is concerned. However, e shall return to it later.

The possibility of correlation with the other mode of esponse appears more likely. However, a difficulty mmediately arises upon closer examination. The response o the step input includes, as pointed out previously, a eaction-time delay of about 0.26-second duration. If the esponse to a sinusoidal function should include a similar elay between input and output, a phase shift of more han twice that observed would result. It is rather fortunate that such a delay is not inserted in all cases between the input and the output of a human control system, as its performance would be very mediocre indeed and acts of skill, such as skating, playing baseball, or even walking, would not have developed as we know them. It is evident that a need exists to explain why reaction-time delay is present in one response and not in the other.



igure 3. **Organization chart of the functions responsible for body movements**

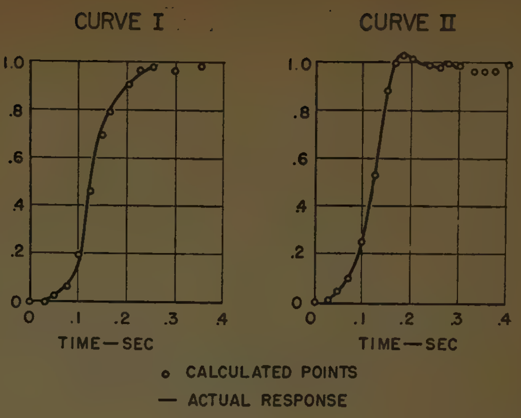


Figure 4. Dynamic portions of response to step input

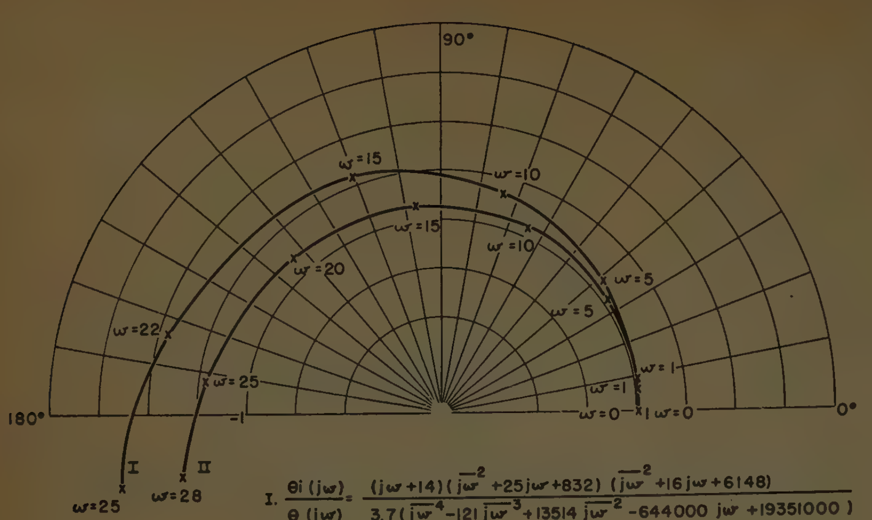
$$\theta_1=1-2\epsilon^{-14t}-1.03\epsilon^{-12.5t}\sin(26t-1.30)-0.06\epsilon^{-8t}\sin(78t-0.12)$$

$$\theta_2=1-1.40\epsilon^{-15.4t}-1.25\epsilon^{-12.3t}\sin(24t-0.5)-0.096\epsilon^{-7.4t}+0.15\epsilon^{-6.4t}\sin(50.6t-0.77)$$

Actually, if our analogy of pilot-autopilot-aircraft corresponds to facts, we should not expect a simple correlation between the response to a step and a sinusoidal input. According to this analogy the reaction-time delay corresponds to the time required to carry out necessary computation and set in the necessary inputs. There should be no corresponding computation and reaction-time delay between input and output in the case of a sinusoidal input, if the response is in closed loop with the eyes as the error-sensing device. A correlation then should be expected between the dynamic portion of the response to a step input and the response to a sinusoidal input, provided the frequency response of the eyes and associated portion of the error-sensing system is high enough with respect to the rest of the system. A transfer function derived from the dynamic portion of the step input then should predict the response to the sinusoidal input. This is found to be the approximate case.

Figure 4 represents the dynamic portions of two typical responses of a human operator to a step function. Mathematical expressions were derived to fit the curves. It may be objected that the mathematical expressions are unduly complicated to fit the variable data. Reasonably accurate curve-fitting was carried out in an attempt to find physical significance to the response and a possible lead to the actual components of the loop. This part of the investigation, however, is still incomplete, and cannot be reported at this time.

The expressions were used to determine the two Nÿquist diagrams represented in Figure 5. It will be noted that a phase shift of about 40 degrees is indicated for $\omega=2\pi$, and that this shift corresponds approximately to that indicated in Figure 2*A* for a sinusoidal input of the same frequency. There is obviously no reaction-time delay between input and output as a reaction-time delay of 0.26 second between



$$\text{I.}\ \frac{\theta i\,(j\omega)}{\theta\,(j\omega)}=\frac{(j\omega+14)(\overline{j\omega}^{2}+25j\omega+832)\,(\overline{j\omega}^{2}+16j\omega+6148)}{3.7(\overline{j\omega}^{4}-121\,\overline{j\omega}^{3}+13514\,\overline{j\omega}^{2}-644000\,j\omega+19351000\,)}$$

$$\text{II.}\ \frac{\theta i\,(j\omega)}{\theta(j\omega)}=\frac{(j\omega+15.4)(j\omega+74)\,(\overline{j\omega}^{2}+24.6\,j\omega+727)(\overline{j\omega}^{2}+13\,j\omega+2601)}{-142(j\omega-92.6)(j\omega+41.4)(\overline{j\omega}^{2}-49.9\,j\omega+3963)}$$

Figure 5. **Human response in Nÿquist form**

input and output alone would cause a phase shift of about 90 degrees which would have to be added to the 40 degrees predicted by the Nÿquist diagram, giving a total phase shift of 130 degrees.

As indicated previously, a sinusoidal response has a definite phase shift with respect to the input for only a few cycles. It is an extremely unstable mode of response and falls very quickly into a synchronous mode without phase shift. To increase the stability of the response, a more complex oscillatory input was used. The input consisted of the sum of three sinusoids which were generated and added in an analogue computer and then recorded on the instrument described earlier. At the same time, a human operator, as represented by Nÿquist diagram II of Figure 5, was simulated in the computer, and the response of this operator also was recorded on the paper. Figure 6 shows a comparison of the response of the actual operator with that of the simulated operator. The over-all technique was devised by Mr. L. A. Payne of the Goodyear Aircraft Corporation. It will be noted that very satisfactory agreement was obtained for the phase shift but that substantial differences exist in the predicted attenuation. It is believed that this attenuation may be caused by a predicting network which is adjusted as a function of the input. The investigation of this type of response is still continuing.

The evidence listed here points strongly to the fact that body movements are controlled in closed loops. Two modes of response have been indicated: an internal mode, in which the loop includes neural center inputs, outgoing neural lines, muscle actuators, sense organs, and return lines; and an external mode in which the eyes act as the error-sensing device. The choice between the two modes of responses is believed to be made on the basis of the predictability of the required motion. Whenever possible the internal loop, involving, as it does, the lowest level of functions, is preferred. It may be interesting to note that certain forms of disabilities, as in the case of ataxia, make it impossible for a patient to operate by internal loop. The mechanism of presetting inputs for an autopilot response seems to be nonoperative in these cases. The diagram may conceivably include, as a still lower function, tools and machines constructed by man—the airplane and boring mill, digital computer, and chess playing machine.

REPEATED INPUT PATTERNS

As indicated, we cannot account for all responses to sinusoidal inputs on the basis of the closed-loop characteristics. The human operator normally can make a great improvement upon the performance associated with these characteristics when the input is of a recurring pattern. We have pointed out that, in some cases of sinusoidal input, the output is nearly synchronous with the input, exhibiting practically no phase shift and little amplitude variation.

We have no analogy for this latter type of response in the airplane system and it does not seem to fit easily into closed-loop theory. It would not be too difficult to modify the autopilot so that this type of response may be simulated. Suppose that a pilot in an airplane was called upon to follow a sinusoidal course. The course may be indicated to him as an input with an oscillating hand. His problem would be to match the oscillation of the input by an oscillation of the output as indicated by his compass or gyroscope. Under these conditions he would certainly not attempt to set the course on his conventional autopilot as he would be forever setting and resetting for the continually variable course. If he took over the control, operating as part of a closed-loop system, the response would have characteristic phase lag and attenuation. Suppose, however, the controls of his autopilot were provided with a sinusoidal drive, the frequency, the amplitude, and the phase of which could be adjusted separately. He then would have sufficient adjustments to cancel all errors between input and output within his ability to detect errors in frequency, amplitude, and phase. He then would be free to go about his higher level functions leaving the autopilot to the low-level task of guiding the airplane.

If we further mechanize our analogy and replace the navigator-autopilot by a system of three servos which are capable of separately detecting errors in frequency, phase, and amplitude, and capable of making necessary adjustments in the autopilot to minimize these errors, the system now is capable of analysis by conventional servo theory. The system operates so that the error at the end of a certain transient period is static rather than dynamic. The shift from a dynamic to a static situation has been made possible fundamentally, by a complete prediction of the future behavior of the input and the elimination of uncertainty with respect to time.

It is possible by means more complicated than those outlined in the foregoing to cause our autopilot to respond to any arbitrary cyclic function with no more than a static ror—provided, again, that the demand on the speed of sponse does not exceed a critical value for the equipment. he problem is one of building up a sort of a cam (or a ble of inputs) and then making corrections to the cam r to the table) as a result of observed errors in successive tempts to follow the input. Ultimately, the error can reduced to a static value within the limit of the equipent's speed of response.

Similarly, the human operator, with a certain amount of aining, can follow a recurring input pattern with only a atic error within, again, the limits of the speed of response the system. The synchronous response of a human perator to a sinusoid was discussed earlier. Figure 7 ows the response to a square wave. It will be noted that e reaction-time delay is eliminated. A certain dynamic ror remains in the response because of the limited speed of e human servo. In the case of a recurring input pattern, is easy to show that the response does not depend directly pon the eyes. If the view of the input is shut off for a ort time, the response will not be affected appreciably. is believed that the mechanism of the human organism analogous to that indicated above for the autopilot. he neural centers must include a mechanism to feed in bitrary function inputs which are constructed as the sult of training. The actual response to the arbitrary puts is believed to be in closed loop.

REDICTION IN THE CONTROL OF BODY MOVEMENTS

WE HAVE INDICATED that both types of responses—the closed-loop and the so-called synchronous responses—volve prediction of the input. The prediction in the st case is a continuous operation on data collected connuously by the eyes; the prediction is the second case is rried out only once and thereafter requires only interittent checks by the eyes to detect any possible drift. he first is called a partial, the second a total, prediction.

The possibility of predicting the future of a variable put depends upon both the nature of the input and that the predicting mechanism. We should speak of the edictability of a function as relative to a predicting echanism. For instance, if a mechanism is able to perate only on the present value of an input, its best ssible prediction is that the input will remain unchanged. it can detect and operate upon both the rate of change d the value of the input, it can predict the future value (a certain interval of time later) by adding to the value of the input another value proportional to the rate of change. This linear interpolation is generally used in closed-loop servos to make up in part for the inherent time delay in the response. However, if carried too far, it may lead to greater error than no prediction. For instance, it can be shown that, for a certain criterion of error, it is better to predict that a sine wave will have a future value equal to the average of its past value than to extend linear extrapolation beyond 90 degrees. In the case of a complex input, a predicting mechanism may combine the operations of smoothing and extrapolating in such a way as to optimize the prediction. Such a mechanism is known as a "Wiener Filter." The mechanism may further adjust its characteristics automatically to optimize the prediction for the particular frequency spectrum of the input and the required time interval of prediction. There is evidence that the predicting mechanism involved in the external closed-loop response illustrated in Figure 6 is of this type.

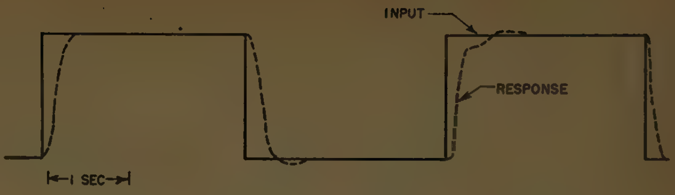


Figure 7. Response to repeated input pattern

Any prediction of the future value of a time function is based upon the assumption that certain of its past characteristics will be maintained in the future. The linear prediction is based upon an operation performed on its observed present characteristics on the assumption that previously observed frequency distributions will be the same in the future. If the input is cyclic, a much better prediction can be made by assuming that the actual values of the function will be repeated periodically in the future as they have been in the past. A suitable mechanism is required for this prediction, and one such mechanism has been indicated in connection with a sinusoidal input. The error of the response then can be eliminated within the limits of speed of response of the system. The situation has been shifted from a dynamic to a static one. We have called this type of prediction a total prediction.

The fact that a human operator can anticipate certain events was well recognized by the earliest experimenters in the field of human dynamics. However, there has been little investigation of this characteristic, which has been generally considered as a disturbing factor in experiments. In the early tests to determine the length of the reaction-time delay, for instance, it was a common practice to give the subject a warning signal before the signal to which he was supposed to respond. It was found that this procedure would often produce impossible negative reaction time. It was realized quickly

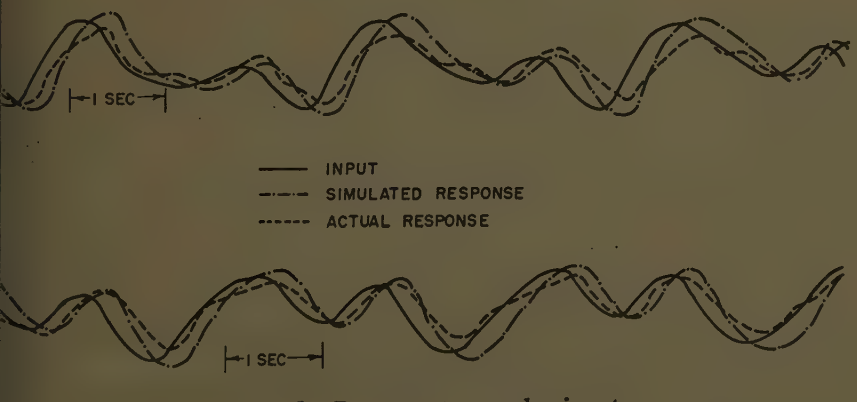


Figure 6. Response to complex input

that the subject would anticipate the key signal to follow the warning signal by a fixed time interval. A special procedure then was devised in order to discourage prediction. For the same reason Tustin and Ellson selected complex oscillatory input or random steps. As has been shown, the complex oscillatory input handicaps total prediction but does not prevent a certain degree of prediction.

As in some man-made mechanisms, prediction may at times cause more errors than if it were absent. This is illustrated in the so-called range effect as reported by Ellson.[5] If a subject is presented with a number of step inputs of approximately the same length and if a much larger step is then presented, the response will be as if the input had been of an amplitude between the small and large steps. It appears that the input is determined by a statistical process in which past and present inputs figure with different weights, the last having the highest weight.

It is interesting to note that Ellson[1] reported, as a paradoxical finding, that the responses to complex waves are linear while the responses to simple sinusoidal inputs are not. Such finding is to be expected on the basis of this discussion. The response to a complex input is in closed loop through the eyes with linear prediction. Total prediction takes place in the case of simple cyclic inputs.

SPATIAL REFERENCE

WE HAVE SEEN that the tendency is for body movements to be carried out autopilot-fashion by closed-loop controls which operate according to directions set up in the neural centers by higher level functions. These directions are in the form of inputs which are matched to feedback signals from proprioceptive senses to produce error signals which, in turn, control the movement. All of this is very well as long as the body remains stationary, but when the body is in motion the neural inputs must be matched with signals from an absolute spatial reference. This reference is believed to be supplied mainly by the vestibule.

The need for such a reference can be illustrated by a simple experiment. Suppose we seat a subject on a revolving office chair in front of a desk. We have said he can pick up a pencil in front of him with his eyes closed if he is first permitted a quick glance to determine its position. He can still perform this operation if he is rotated 90 degrees after looking at the pencil and closing his eyes. Such an act requires an absolute spatial reference.

A further simple experiment demonstrates that the vestibular organs are mainly responsible for supplying this spatial reference. If our subject is rotated at a constant velocity for a period of time, suddenly stopped, asked to open his eyes for an instant to ascertain the position of the pencil and finally point his finger at the pencil, his finger will be observed to drift in the direction of the previous rotation. This phenomenon is known as past-pointing and can be shown to be as a direct function of a false velocity signal issued by the semicircular canals.

The vestibule is believed to provide positional reference by a process of double integration of acceleration.[7] The first integration takes place in the vestibule which issues signals proportional to velocity. These signals appear to be integrated in turn in the neural centers. The vestibule issues signals which are proportional to velocity only within a limited range of frequency. Under certain conditions, as in the past-pointing experiment, the vestibule may issue completely erroneous signals.

DISCUSSION AND CONCLUSIONS

WE HAVE ATTEMPTED to outline a system of the mechanism of body control. In a necessarily incomplete theory, we have tried to obtain an over-all integrated view of the mechanism at a sacrifice of details and at the risk of outright misrepresentation. We have generally emphasized the following features of the mechanism:

1. The hierarchical organization of the various functions involved in body movements.
2. The closed-loop characteristics of body movements.
3. The factor of prediction.

The engineering aspect of the mechanism of body control is a limited one. The psychological aspect is still undefined. There is need to join forces in the struggle for more breathing space in both fields. We could make little claim to understanding the movement of freight cars in a sorting yard without a knowledge of the over-all plan of which its operation is a part, of the higher human level functions which implement this operation by maneuvering signals and switch controls and, perhaps, of the still higher functions which conceived the plan. Similarly our understanding of behavior, even in its simplest form as in body activity, must be very limited unless we have some insight into the high-level nonphysical world of the conscious where the policies which govern all behavior are formulated and implemented.

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The Development of Engineering as a Profession

R. D. HENSON

RECENTLY an Illinois town installed parking meters with the agreement that "professional men" should be granted parking privileges at a fixed rate per onth. When a local engineer applied for this professional ense, he was at first refused on the ground that he was not "professional man." On reconsideration, he was re- tantly granted a license along with the local lawyers d medical practitioners, but the town officials are still t convinced that an engineer possesses professional status. doubt the same reaction would occur if a similar situa- n arose in most American towns and cities.

Some ideas have not changed much since 1711 when seph Addison wrote in *The Spectator:* "I am sometimes y much troubled when I reflect upon the three great ofessions of divinity, law, and physic; how they are h of them overburdened with practitioners, and filled th multitudes of ingenious ntlemen that starve one other."[1] In the thinking many people there are still t these three professions, hough a person holding h an opinion would find incongruity in including gery with medicine today. e idea that engineering is profession would startle ne people as much as the idea that engineering is not a ofession would startle most engineers. Engineers have en working for professional recognition for a long time. y have they not succeeded?

Many people still feel there are only three professions: divinity, law, and medicine. Why is engineering not considered a profession by some? To answer this, Mr. Henson gives the historical background of the profession, the beginnings of the engineering societies, and the development of engineering schools.

EARLY HISTORICAL BACKGROUND

NOT SO LONG ago Nicholas Murray Butler said, "The best definition of engineering that I have ever seen hat it is the direction of the sources of the power of ure, the bridge over which man passes to get into nature control it, to guide it, to understand it, and the bridge r which nature and its forces pass to get into man's d of interest and service."[2] If this is what we mean by gineering—and the definition comes from the 1828 arter of the Institution of Civil Engineers in England— n engineering as an art, science, craft, vocation, or what e you, is not new. Over 2,000 years before Christ a draulic engineer in China was made emperor as a ard for successfully devising a way to control flooding ers.[3] Almost 3,500 years ago the great Egyptian gineer-architect Senmut was rewarded for his work by ng made a nurse to Queen Hatshepsut's daughter.[4] long as we have had recorded history, men have been doing work which we today would classify as engineering, yet engineering is thought of as a newcomer to the professional ranks, when it is thought of as being a profession at all.

The reason for this is probably that it is only in comparatively recent times that we have had a distinct group of people practicing exclusively what we have come to call engineering, and it was only with the emergence of this group that we found a word to describe their activity. The Greek word "architect," meaning "chief builder,"[5] sufficed through many centuries to describe a person who was a builder in a very broad sense; that is, one who erected buildings, constructed irrigation works, built ships and machines, and did much work that today would be considered in the field of engineering.[6]

A "Superintendent of Works," who had charge of the construction and repair of public edifices and roads, existed in Egypt as early as 3700 B.C.,[7] and the army officers, who were well educated, performed all kinds of engineering work, from transporting stone to building canals,[8] but there appears to have been no separate and distinct group of men who were educated for the sole purpose of practicing what would now be called engineering. Members of the nobility and the priesthood performed necessary engineering functions, if they were so inclined, simply because of their position, and in addition to other duties.

A similar situation prevailed in Rome. According to Plutarch, the first bridge over the Tiber was built by the first king of Rome, Ancus Marcius, who reigned from 641 to 616 B.C., and its custody and maintenance were attached to the priesthood.[9] Later when the Roman Empire was formed, the building of roads seems to have passed to the soldier-engineer who was present when the need for roads arose. From the downfall of Rome in the fifth century to the beginning of the 16th century, the sciences were almost lost, except in so far as they were kept alive by the monks and other religious organizations.[10]

NONSECULAR CHARACTER OF UNIVERSITIES

LAW, DIVINITY, and medicine fulfill needs which are felt by even the most primitive of peoples; engineering as engineering does not. Moreover, in an advanced

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civilization practitioners of divinity, law, and medicine tend to be learned men who draw attention to their work, while until recently, historically speaking, it was more important for engineers to be inventive and ingenious than for them to be able to read and write. (James Brindley, a very famous English engineer of the 18th century, was practically illiterate, which makes his accomplishments all the more remarkable, for he was largely unable to profit by the recorded experience of others.[11])

The word "engineer" apparently came into existence in the 14th century to refer to military men who were doing work of a civil character,[5] and the term "civil engineer" has been used ever since the 18th century to distinguish the civil from the military branch of the work.[5] But when civil engineers, in an antithetic sense, came to be recognized in England, they were not the educated men of the time. Indeed, even after the Renaissance the Universities of Oxford and Cambridge did not include in their curricula subjects which had any practical application to engineering problems, and this is not surprising. At this time the influence of the Church over the English universities (and Continental universities, for that matter) was tremendous. Students were clerks and, after finishing their training at the university, if they chose to go on in the vocations which have since become recognized as professions, the taking of minor or major orders was usually necessary for advancement, for the king or bishop found conferring an ecclesiastical office less expensive than paying a salary. Such was the position of the physician, the lawyer, the teacher, the adviser. (By the 15th century, the Inns of Court were established in England so that the secular lawyers were no longer directly under Church influence; the surgeons were organized in a secular guild in the 14th century, but their social position declined; and by the middle of the 16th century surgery was no more than a trade, the surgeons and barbers being united into a single guild with tooth-drawing as their practice in common.) With the exception of teaching, however, the professions largely had become secularized by the end of the 16th century.[12,13]

THE THREE PROFESSIONS

The word "profession" came into use in the 16th century to denote particularly the learned vocations of divinity, law, and medicine,[5] and at this time engineering as we think of it could scarcely be said to have awakened from the Dark Ages, so it could not possibly have been ranked with these three ancient and honorable vocations.

When Addison wrote about the three professions, he expressed the social feeling of his time, for the professions were thought to be solely for gentlemen. The Church influence is obvious, for medicine and law had in the recent past been closely associated with divinity. The professions today are intimately related to the business of living, as they were in Addison's time, although the very personal relation of lawyer and client, physician and patient, and engineer and client, is no longer as close as it once was, due to the complexities of life brought about by the emergence of engineering—an emergence so important and violent as to give to the period the name of the Industrial Revolution.

DEVELOPMENT OF PROFESSIONAL RECOGNITION

THE TYPE AND extent of engineering development hav always depended principally upon reaching such state of civilization that a need created by the physica environment is recognized and, economically speaking, i capable of solution. This was true in ancient Egypt wher irrigation was developed to make use of the annual overflowing of the Nile. The aqueducts of the Romans me an environmental need when the Romans had reached stage of development in which they could recognize that need existed that could be satisfied. When the state c civilization declined, engineering progress ceased, and i remained dormant during the Dark Ages, for the mos part.[10] Civil engineering reappeared in Italy in the middl of the 17th century due to a demand to drain the swamps and it developed in France at about the same time becaus of the need of an internal communication system in th development of commerce.[14] In England engineerin growth was made possible by the accumulation of wealt which followed the great period of exploration and discovery, and it "burst into full flower" after Watt's inventio of the steam engine.[15]

In the early 18th century in England the millwright were the only engineers, and in the country these millwrights had to solve engineering problems as they arose and solve them they did—by using their own resource and imagination.[16] As the need for mechanical skil increased with the progress of manufacturing and agriculture, these men met the increasing needs with increasin skill; they became learned in their fields; and by 177 they had reached such a stage in their development tha the Society of Civil Engineers was founded as a dinin club where they could exchange ideas.[17] This date mark an important step in the emergence of engineering as profession, for it is a step along the way traveled by th great, acknowledged professions.

What we now think of as a profession may be said t come into existence when a number of persons are foun to be exercising a particular technique, based on specialized training of a high intellectual caliber, whos practice must require the exercise of intelligence and discretion.[18] And when widely recognized professional group have emerged in our Anglo-American society, they hav followed a fairly common pattern.

As the various groups which are classified as professiona have emerged with their specialized intellectual training professional associations have been formed at such time a the practitioners realized that they possessed a certai craft that should be distinguished. The public at larg is not apt to recognize that those possessing certain qualifications are alone entitled to be called by a particula name, and the desire of the well qualified to separat themselves from the ill- or unqualified leads to a professional association formed from those possessing certai minimum qualifications. A professional association i based on a common subject interest, of course, but it is no formed for the purpose of study alone. If it were, it woul be a subject association, many of which exist. A study c subject matter is only part of the work of a true professiona association; it is not the sole object.

In addition to the desire to separate the qualified from e unqualified, there is another motive: to distinguish the rupulous from the unscrupulous by setting up and main- ning a proper standard of conduct. This not only otects the public but also gives the profession a good me. Incidental to the raising of qualifications for embers of the group, the problem of educational prepara- n arises, and the profession exerts its influence here.

Whether expressed or not, a strong incentive toward sociation is the raising of the status of the members of e group. The newcomers to professional ranks are oked down upon and not accepted as professionals until ey have convinced the public that they alone are qualified render certain services.[19]

FIRST SOCIETIES FORMED

THESE STEPS toward professional recognition were followed by the engineers in England. The Society of vil Engineers, founded in 1771, did not satisfy existing eds, so the Institution of Civil Engineers was founded in 18 as a study association, but, as time went on, it broad- ed its interests and became a true professional association. specializations in engineering multiplied, various spe- alist associations were formed, but not as rivals of the rent either in interest or membership.[20]

In the United States the first successful national organi- tion was the American Society of Engineers and Archi- cts, founded in 1852, inactive from 1855 to 1867, and then vived as the American Society of Civil Engineers SCE).[21,22] This Society, by a constitutional amendment 1873, made eligible for membership "Civil, Military, eological, Mining and Mechanical Engineers, Architects, d other persons who, by profession, are interested in the vancement of science."[23] This attempt to be all- clusive failed, however, as The American Society of Me- anical Engineers was founded in 1880 because it was t that the existing societies were not suited to a discussion mechanical engineering problems,[24] and the American stitute of Electrical Engineers was founded in 1884.[24] he American Institute of Mining Engineers was founded 1871 and instead of merging with the ASCE after the endment of 1873, continued its independent existence, anging its name in 1919 to the American Institute of ining and Metallurgical Engineers.[24]) With the growth the many recognized specialties now existing in engineer- , new societies have been formed as rapidly, it would pear, as new names could be thought up. The result that there is no one organization which can speak thoritatively for all engineers.

While all lawyers do not belong to the American Bar sociation (ABA) and all doctors do not belong to the nerican Medical Association (AMA), this seldom seems be noted when either group takes a stand on a public ue. These organizations are unquestionably profes- nal associations. They have a common subject interest, y have standards of conduct, they are concerned with qualifications of their members, and, if they no longer ed be concerned with raising the status of their members, y at least attempt to preserve the status quo. No one gineering organization even remotely approaches the influence of the ABA or the AMA, for no one engineering organization really represents all engineers. The need for a unified organization is widely felt today, but the need has not yet been met.[25]

That engineering societies are interested in the qualifications of those practicing engineering is shown not only by the qualifications set up by the individual groups for their members, but also by the work done to have registration laws passed in all the states. If there is any need for registration of engineers so far as the public is concerned, it is not analogous to the licensing of lawyers, physicians, surgeons, or dentists, any of whom may be needed at a moment's notice to provide some essential service when there may not be time to investigate the qualifications of the person called. Moreover, while licensing laws set up a minimum standard for those to whom they apply, all engineers are not now covered by these laws. Licensing alone does not make a profession, however, for if it did midwives and funeral directors and plumbers would belong to professions, and no matter how essential those occupations may be, they are not professions. The existence of the Engineers' Council for Professional Development (ECPD) and the American Society for Engineering Education shows the interest engineers have in these fields. It is significant that the Report of the Committee on Professional Recognition of the ECPD included as one of the attributes of a profession, "It must have group consciousness for the promotion of technical knowledge and professional ideals and for rendering social services."[26,27] If a set of ethics, such as has been formulated by the ECPD,[28] were inculcated into the engineering student, the inimicality of his belonging to a labor union would be more apparent to him when he goes into the practice of engineering.

Lawyers and doctors have single organizations which perform the work of the several engineering subject associations plus the work of the special purpose groups, and their results are worth emulating, at least if engineers desire general recognition for their profession. For engineering certainly is a profession by the generally accepted standards; what is lacking is widespread public recognition of the accomplished fact.

DEVELOPMENT OF ENGINEERING SCHOOLS

EDUCATION HAS created the problem and in education lies the answer. A profession requires education. Only when engineering began to require specialized intellectual training did it begin to emerge as a profession, but while education has made engineering a profession, it has also inhibited its growth as such. In the United States of 100 years ago, engineering schools trained bridge, road, and railroad builders, while most engineers were trained in shops or else took the conventional Bachelor of Arts course with a few courses in engineering.[29] The trend in engineering education has been from the general to the specialized back to the general.

The first curriculum offered at Rensselaer Polytechnic Institute in 1824 took one year for completion and was divided into three terms. "School opened the last week in July with an 'experimental term,' during which the students gathered botanical, mineralogical, and zoological specimens, visited shops and factories near the school, and discussed with the class the significance of what they had collected and observed. In addition each student gave a number of lectures on chemistry and natural philosophy, fully illustrated by experiments performed with his own hands. During the second term, from the end of November to the first of March, the students reviewed in class the sciences taught in the fall, and in addition studied rhetoric, logic, geography, and mathematics. The spring term lasted from the first week in March to the end of June. For six weeks the work consisted of lectures by the students on experimental philosophy, chemical powers, substances non-metallic, metalloids, metals, soils, and mineral waters. For the remaining nine weeks the students were exercised in the application of the sciences to practical projects and in the study of engineering works in the neighborhood of the school."[30]

The Rensselaer Institute changed from a school of natural science designed to train teachers into a school of engineering and technology, and its curriculum was revised from time to time, a new curriculum being adopted in 1849 to incorporate some ideas from the more theoretical French schools, and the course was lengthened to three years, the first half being used to give a general scientific basis of all engineering and the second half being devoted to specialization.[31]

When engineering curricula were adopted later by other schools, the Rensselaer influence loomed large. The curriculum adopted at the University of Illinois in 1867 for the first three years included in the first year algebra, geometry, trigonometry, descriptive geometry and drawing, English or foreign language, history, and botany; in the second year analytics, calculus, descriptive geometry, drawing, surveying, foreign language; and in the third year calculus, analytic mechanics, descriptive astronomy, railroad surveying, shades, shadows, perspective, physics, and chemistry. The fourth year was devoted to more technical courses. At Illinois the instruction in theory was by lecture and recitation from textbooks, and plates and models were used, along with shopwork allowing the construction of machinery which had been planned in the drafting room. In the process of constructing machinery, the students earned money sufficient in some cases to pay their expenses. At Rensselaer by 1865 the method of instruction was by questioning and blackboard demonstration, rather than the student instruction which had formerly been used.[32]

With the establishment of more engineering schools, the problem of a proper education received due attention. At the annual meeting of the ASCE in June, 1874, Mr. Thomas C. Clarke read a paper on "The Education of Civil Engineers" in which he said that the object of education "is to enable us to know ourselves and to know the laws of nature . . . Those persons who have come to the study of Civil Engineering after a thorough training in both natural science and also, to use the good old expression, 'the humanities,' are those who make the most rapid progress. When a man has learned how to learn, he can quickly learn anything."[33] Despite the merit in this view, the trend in education turned more toward specialization, a natural result of new developments in engineering and of the growth of a body of teachers who had received an engineering education, as the early teachers had not.

PROBLEMS OF SPECIALIZATION

THE PROBLEM of specialization has not been confined to engineering but has invaded almost all fields of knowledge. The recent Harvard report on "General Education in a Free Society" stated: "It would seem clear that communication on an advanced level is impossible unless those who are seeking to communicate with each other have some common body of knowledge and ideas, as well as some training in the analysis of values and of relationships. The undergraduate, whether he be a concentrator in the sciences, the humanities, or the social sciences, should be able to talk with his fellows in other fields above the level of casual conversation. He should share in a common awareness of the importance of ideas and objectives, in a common understanding of the heritage which is the possession of his generation. Nor will general education at the college level have been entirely successful unless the student has acquired some understanding of the principal respects in which their aims and methods differ."[34]

The opposition to a liberal education can be traced to historical causes, for liberal education arose in a slave-owning society like ancient Athens where the ruling class did nothing, but had a liberal education so as to enjoy life, each in his own way, while the slaves were trained in specialized work. Such a society no longer exists but the need for that type of education has not diappeared. "Democracy is the view that not only the few but that all are free, in that everyone governs his own life and shares in the responsibility for the management of the community. This being the case, it follows that all human beings stand in need of an ampler and rounded education."[35] While specialization is a product of our society, "in order to discharge his duties as a citizen adequately, a person must somehow be able to grasp the complexities of life as a whole . . . The aim of education should be to prepare an individual to become an expert both in some particular vocation or art and in the general art of the free man and the citizen. Thus the two kinds of education once given separately to different social classes must be given together to all alike."[36]

Besides the civic duties which have gone unheeded because specialization in engineering gave no time to arouse an educational interest in them, social and business deficiencies have also handicapped the specialist. Recognition of these factors has started a trend back to general education in the undergraduate curriculum with specialization at the graduate level. President Davis of Stevens Institute of Technology has observed that adaptability has become increasingly more important to the young graduate than proficiency in a particular field because of the rapid changes now being made. Besides the new and, at present unknown fields which may be opened up, fields of specialization which now seem important may not present the same opportunities in a few years. Thus a broad general background in science and engineering becomes increasingly more important.[37]

awyers and doctors have succeeded in their fights to uire a combination of unspecialized undergraduate and ialized graduate training, so it is not unnatural for ineers to follow this lead, feeling themselves entitled imilar respect as members of a profession.

ome elimination of courses in the engineering curlum has been made possible by differentiating between ative work and techniques, reserving the former for the ineering school and the latter for the trade schools. gineering schools have been further aided by the large ustrial companies which have training programs to ch their young employees any necessary techniques.[38] problem of further elimination of unnecessary courses been stated with unusual frankness by Dean Finch of umbia: "Unfortunately, faculty members interested in articular branch of engineering have clung tenaciously the belief that any student who received a degree in ir branch must be required to take practically all the plication courses in special techniques which had accuated over the years and were traditionally regarded as hin the scope of this branch. This was a natural reion. These were the specialties to which many teachers l devoted their entire interests, teaching efforts and eers, and on which such reputation as they had achieved ed."[39]

The aim of a general education is at least in part to allow of us to share our common heritage and to understand world and each other better. A narrow, technical ication, instead of furnishing an incentive for its recipient read widely and to investigate others' problems on his n initiative, probably tends to make one more reclusive n ever. The tendency of a narrow education to cause row interests may account for the lack of interest shown most engineers in public affairs, and, consequently, to a lack of a single association which can speak for all ineers on public matters, for the failure to include a gle engineering or scientific society among more than organizations chosen by the United States Government attend the United Nations Conference in San Franco[40]—to mention only one instance when engineers could e made a contribution to the world but did not.

Recognizing the deficiencies which unquestionably exist engineering education, the trend is toward a general ication, with specialization at the graduate level. The lergraduate education is general both as to engineering jects and as to other fields of knowledge.[38,41] In time, en the many have acquired the interests held now by the the need for a great, unified organization will be met, the engineers will receive proper recognition as proional men. The public expects leadership from mems of a profession, and engineers individually and collecly must be prepared to meet that expectation and to ill their obligations with distinction.

Vill engineering ever become a profession in the eyes of public? The answer may lie in a paraphrase of an saying: "United we can, divided we fail."

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Simplification of Liquid Cooling for A-C Turbine Generators

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The design of liquid-cooled turbine generators has been simplified by eliminating some complications first thought necessary and enumerated in an earlier paper.[1] The external deaerators and small ducts below the rotor's main slots may not be omitted; the stator can be cooled with water instead of by an insulating liquid; and complications associated with hydrogen may be obviated in small and moderate size generators by operating in an air atmosphere.

IN A PAPER[1] presented before the AIEE in 1947, a combination of three cooling media was advocated for large turbine generators: (a) oil (or equivalent synthetic liquid) for the stator, (b) water for the rotor, and (c) hydrogen for the internal surroundings of the stator and rotor. From the thermal standpoint, this combination is believed to be superior to any other, but the opinion has been expressed that complications are involved.

For simplification, these conditions now are proposed:

1. For small and medium generators, the coolant in the ducts is water for stator and rotor, with air in the internal surroundings. For the large machines, the coolant in the ducts is water for stator and rotor, with hydrogen in the internal surroundings. With these changes the complications associated with oil for the stator would be eliminated, as well as the complications associated with hydrogen for small and medium machines. The coil ends for both stator and rotor would be cooled by the internal gas, as suitable small internal heat exchangers would be provided.
2. All internal water systems could be paralleled externally, and one external heat exchanger, circulating pump, and so forth, could be used for all.
3. The external deaerator is to be omitted, as it was found to be unnecessary.
4. The small ducts below the main slots in the rotor are to be omitted, as the water in the teeth ducts provides ample cooling.

Simplifications, brought out in the earlier paper, are:

5. Omission of internal fans.
6. Omission of the large internal heat exchangers. (Small internal heat exchangers would be needed for the gas for the coil ends.) One external heat exchanger would be used for most of the losses.
7. Omission of vent ducts for the stator and rotor. (Water cooling ducts are to be substituted for them.)
8. Omission of ducts for coolant flow to and from the internal heat exchanger.

Referring to item 6, the heat flow in the external heat exchanger is from water to water, instead of from hydrogen (or air) to water. Therefore, the heat exchanger size will be reduced. The frame diameters of hydrogen-cooled machines are muc larger than they would b with liquid cooling, becaus the gas-to-water heat exchangers must be placed internally, and the external diameters of the stator cores ar appreciably larger. As th frame and end bells of a hydrogen-cooled machine ar made to withstand an explosion, a large frame diameter i costly. Also, the external heat-exchanger tubes need not b provided with rather costly fins, as needed with hydrogen or ai

WATER-COOLED STATOR

A LONGITUDINAL SECTION of a water-cooled stator an rotor is shown in Figure 1. Two alternative scheme for the stator are shown in transverse section in Figure 2 Square or rectangular metal tubes are used, through whic water (treated with a corrosion inhibitor) flows, instead c the usual vent duct spacers, but now the cooling is effecte only through the water in the tubes. These tubes serv the dual purpose of cooling and of supporting the long tudinal pressure of the laminations. In Figure 2*A* add tional supports are provided, but in Figure 2*B* the spiralle tubes in the core portion afford ample cooling surface an may be made to provide adequate support. The arrang ments indicated afford effective means for transferring th generated heat in the tooth-slot and core zones in accordance with the loss density therein. The designer ca determine the number of tooth zone tubes to connect i series after the losses have been calculated.

For the rotor and stator coil ends, gas streams pa between consecutive coils. The high centrifugal forc are ample to secure adequate volumes of flow. Hig velocities at the coil surfaces are insured by suitable bloc ing for both the rotor and stator coil ends. Although suc high velocities reduce the volume of flow slightly, the ga in velocities insures the relatively high heat transfer ra needed.[2] Calculations indicate that it is then possib to secure about the same temperatures as for the embedde

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Essential text of paper **50-28**, "Liquid Cooling of A-C Turbine Generators—Part I recommended by the AIEE Committee on Rotating Machinery and approved by AIEE Technical Program Committee for presentation at the AIEE Winter Gene Meeting, New York, N. Y., January 30–February 3, 1950. Published in AIEE *Tra actions*, volume 69, part I, 1950, pages 165–73.

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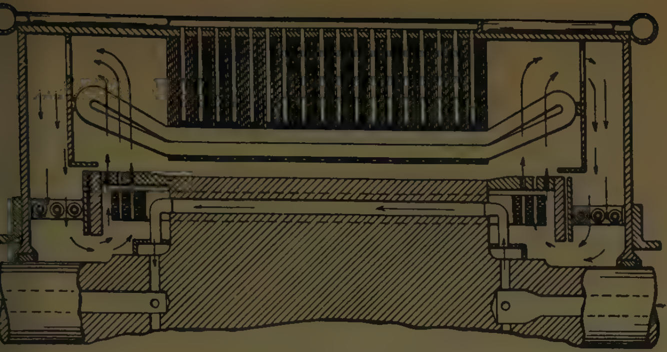
In connection with the hydraulic model, the author acknowledges the helpful suggesti of K. L. Hansen, E. F. Vilter, Dr. J. F. H. Douglas, and several other Allis-Chalm engineers; he also thanks the Allis-Chalmers Company for the loan of some of apparatus. He thanks the Milwaukee School of Engineering, and especially F Wutschel of the school's faculty, for facilities and aid in testing. The Louis Allis Co pany balanced the rotating parts before water was put into the model.



igure 1. **Longitudinal section of a water-cooled stator and rotor**

opper (with water in the rotor ducts). It has been laimed for hydrogen-cooled rotors that lower coil-end emperatures are obtainable with the rotor blocking than or the ventilated embedded parts.[3] For the stator coil nds, with their thick walls of insulation, the external urface heat densities are much lower than for the rotor, nd sufficiently low temperatures should be obtainable.

As shown in Figure 1, the coil-end gas streams pass hrough internal stationary heat exchangers. A stationary isc (attached for convenience to the exchanger's inner side) revents pressure generated by the rotating rotor end disc rom interfering with the radially inward gas flow.

RELATIVE RATINGS

ALL LARGE turboalternators, supplying loads for which the current lags the voltage, are limited by rotor opper heating. In this study the rotor ampere turns for given temperature rise are compared for various cooling edia. The following are said to be the same for any wo rotors that are to be compared: (1) number of poles nd frequency; (2) thickness of, and materials in, insulation all; (3) slot dimensions, their number and spacing; 4) rotor diameter; (5) steady-state average copper emperature; (6) space factor of copper in a slot; (7) pecific resistance of the rotor copper. These items are he same, but the cooling media are changed. In general, he cooling ducts for liquids are narrower than for gas, ut that does not affect the derivation and conclusions. he following symbols will be used:

=cross section of one rotor conductor in square inches
=number of rotor conductors per slot
=depth of rotor slot below wedge in inches
=rotor external diameter in inches
=rotor current per conductor in amperes
$_1$=coefficient for temperature drop through wall of slot insulation; the approximate thermal conductivity of wall in watts per inch per degree centigrade
$_2$=coefficient for all other rotor temperature drops in watts per square inch per degree centigrade
$_3$=space factor in rotor slots=CA/Sd
=number of rotor slots per group
=number of poles
=width of rotor slot in inches
=thickness of single wall of rotor insulation in inches
=total mean temperature rise of rotor copper in degrees centigrade
=temperature drop through wall of rotor insulation
=temperature drops other than θ_1 (so that $\theta=\theta_1+\theta_2$)
=specific resistance of rotor copper in ohms per cubic inch
=pole pitch on rotor periphery in inches

The total temperature rise of the copper is

$$\theta=\theta_1+\theta_2=\left(\frac{\rho CI^2}{A}\right)\left(\frac{t}{2(s+d)K_1}+\frac{pn}{\pi DK_2}\right) \tag{1}$$

Substiting K_3Sd/C for A and τp for πD, and solving,

$$CI=\sqrt{\frac{\theta K_3Sd}{\rho}}\sqrt{\frac{1}{\dfrac{t}{2(S+d)K_1}+\dfrac{n}{\tau K_2}}} \tag{2}$$

The rating is evidently proportional to the ampere conductors per slot CI. Suppose that, in one combination of coolants, the rotor is operated in certain gaseous surroundings, with the coolant in the ducts separately defined; this combination is referred by subscript I. These ampere conductors are to be compared with those of another combination for which subscript II applies. All quantities under the first radical in equation 2 are the same for the two combinations, and it therefore drops out in the comparison ratios.*

$$\frac{(CI)_{\text{I}}}{(CI)_{\text{II}}}=\sqrt{\left[\frac{t}{t}\,\frac{\tau(K_2)_{\text{II}}+2n(S+d)(K_1)_{\text{II}}}{\tau(K_2)_{\text{I}}+2n(S+d)(K_1)_{\text{I}}}\right]\left[\frac{(K_1)_{\text{I}}\,(K_2)_{\text{I}}}{(K_1)_{\text{II}}(K_2)_{\text{II}}}\right]} \tag{3}$$

The ratio of ratings is then dependent upon the coefficients K_1 and K_2 and upon the choice of slot proportions. The coefficients are determined in the following manner.

From laboratory tests on transverse thermal conductivity of mica plate in air the composite's thermal conductivity was found to be about 0.003 watt per inch per degree centigrade. To arrive at numerical values for the ratio in equation 3, the slot lining in a turborotor is taken as 0.0625 inch thick, and the area per inch axially through which the heat flows is the arithmetical mean between the slot surface, 2 $(S+d)$, and the copper surface. For simplicity, the surface per inch axially is taken as 2 $(S+d)$, and as such surface is about seven per cent more than the mean, the equivalent transverse conductivity becomes $K_1=0.003/1.07=0.0028$.

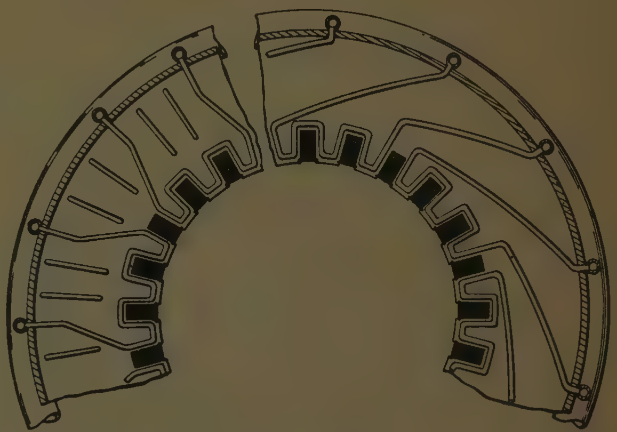


Figure 2. (A, left). Traverse section of a water-cooled stator showing added supports; (B, right). Traverse section of a water-cooled stator with spiraled tubes which supply adequate support

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* Generally, with liquids, the ingoing temperature is lower than for gases, and as the maximum temperature is the limitation, the allowable temperature rise, θ, with liquids should be greater than with gases, thereby making the rating ratio even more favorable for liquids than given by equation 3.

Table I. Comparison of Ratings of Turborotors with Various Cooling Media

	Combination I			Combination II			Rating Ratio: (Ampere turns)I / (Ampere turns)II	Coefficients				Rotor and Proportions					
	Surroundings			Surroundings				Combination I		Combination II							
Item Number	Fluid	Number of Atmospheres of Pressure	Duct Fluid	Fluid	Number of Atmospheres of Pressure	Duct Fluid		$(K_1)_I$ (Insulation)	$(K_2)_I$ (Other)	$(K_1)_{II}$ (Insulation)	$(K_2)_{II}$ (Other)	Number of Poles	Frequency, Cycles per Second	Rotor External Diameter, D, Inches	Slots per Group	Slot Width, S, Inches	Sl Dep Bel Wed d Inc
1	H_2	1	H_2O	Air	1	Air	2.06	0.0056	1.00	0.0028	0.083	2	60	34	14	1.00	5.
2	H_2	1	H_2O	H_2	1	H_2	1.62	0.0056	1.00	0.0056	0.121	2	60	34	14	1.00	5.
3	H_2	1	H_2O	H_2	2	H_2	1.39	0.0056	1.00	0.0056	0.193	2	60	34	14	1.00	5.
4	H_2	1	H_2	Air	1	Air	1.27	0.0056	0.121	0.0028	0.083	2	60	34	14	1.00	5.
5	H_2	2	H_2	H_2	1	H_2	1.164	0.0056	0.193	0.0056	0.121	2	60	34	14	1.00	5.
6	H_2	2	H_2	Air	1	Air	1.48	0.0056	0.193	0.0028	0.083	2	60	34	14	1.00	5.
7	Air	1	H_2O	Air	1	Air	1.54	0.0028	1.00	0.0028	0.083	2	60	34	14	1.00	5.
8	H_2	1	H_2O	Air	1	Air	1.91	0.0056	0.85	0.0028	0.083	2	60	20	8	1.00	3.
9	Air	1	H_2O	Air	1	Air	1.42	0.0028	0.85	0.0028	0.083	2	60	20	8	1.00	3.
10	H_2	1	H_2O	H_2	1	H_2	1.74	0.0056	1.00	0.0056	0.121	4	60	55	10	1.25	8.
11	H_2	1	H_2O	H_2	1	H_2	1.695	0.0056	1.00	0.0056	0.121	4	60	50	8	1.375	8.
12	H_2	1	H_2	Air	1	Air	1.260	0.0056	0.121	0.0028	0.083	4	60	55	10	1.25	8.
13	H_2	1	H_2	Air	1	Air	1.260	0.0056	0.121	0.0028	0.083	4	60	50	8	1.375	8.
14	H_2	1	H_2O	Air	1	Air	2.19	0.0056	1.00	0.0028	0.083	4	60	55	10	1.25	8.

In an atmosphere of hydrogen most of the air particles in the slot liner are supplanted by hydrogen, the thermal conductivity of which is about seven times that of air. Experiments indicate that the composite's conductivity is thereby approximately doubled, and consequently it has been taken as 0.0056.

From a large number of tests on ventilated turborotors in air, the average value of K_2 was found to be about 0.083 watt per square inch per degree centigrade. Comparisons with data from G. E. Luke's paper[4] on a revolving cylinder (plotted on log-log paper) show somewhat greater values. (At such high peripheral velocities the heat transfer rate does not change much with the speed.) The two probably are different because (1) the air windage loss augmented the temperature of the actual rotor more than for Mr. Luke's model; (2) the internal drop in the steel in the actual rotor increased the copper temperature (this drop was zero in the model); (3) heating of the air and inequalities in distribution of air in the radial vents which produce inequalities in copper temperatures. K_2 will be taken as 0.083 for air.

The heat transfer rate with hydrogen at one atmosphere is about 1.46 times that of air at one atmosphere. With hydrogen the windage loss does not augment the temperature appreciably, but the internal drop in the steel would be the same as for air for the same flow of heat; in hydrogen, with larger heat flow, this drop is greater. One of these would have the effect of increasing the coefficient K_2 and the other of decreasing it. It is believed that little error is introduced by taking K_2 for hydrogen (at one atmosphere pressure) to be 1.46 times that for air, that is, 0.121.

For hydrogen at a pressure of two atmospheres, the heat transfer rate from the surface is approximately $(2)^{0.8}=1.74$ times that for one atmosphere. However, with the larger heat flow in the steel, there would be lower cylindrical surface temperature for a given internal copper temperature, which means less heat transferred for a given internal temperature. For simplicity, take it to be $(1.8)^{0.8}=1.6$ times that at one atmosphere, or 0.193 watt per square inch per degree centigrade.

Several rotors were calculated with water in rectangular ducts. In such cases, when the power loss is referred to the rotor's cylindrical surface, the total drop beyond the wall of insulation gave an equivalent K_2 of approximately 1 watt per square inch per degree centigrade, or more, f the larger rotors, and 0.85 for the smaller. This to account of the water's mean temperature rise, the drop the teeth, and also the drop which occurred at the surfa of the ducts.

In Table I, a combination is defined by (1) the surroun ing fluid, (2) the pressure of that fluid, and (3) the flu in the ducts. Table I shows the ratings of turboroto with various types of cooling media.

For large rotors, the preferred combination is surroun ings of hydrogen at one atmosphere pressure and wat in the ducts. For medium and smaller ratings, it is b lieved to be desirable to operate in an air atmosphere wi water in the ducts, thereby reducing the complicatio associated with hydrogen. All items in Table I, exce items 7 and 9, pertain to large ratings (of the order 100,000 kva) and items 7 and 9 apply to about 10,000 kv The ratio of ratings in column 7 is taken as the ratio rotor ampere-turns, as given from equation 3.

HYDRAULIC MODEL

The construction and tests of a hydraulic model we undertaken chiefly to dispel the fears of those w doubted that a liquid could be passed through a hig speed rotor without giving trouble.

The model was driven by a 2-pole 60-cycle inducti motor at nearly 3,600 rpm. Figure 3 is the longitudin section of the model. Figure 4 is a diagram of t model's external hydraulic system. The liquid used w water plus a suitable corrosion inhibitor; operation was a closed system. The losses were so small that no he exchanger was needed.

The Inlet End. The water enters through the stationa pipe $A-B$ (Figure 3) located in the hollow rotating sha then flows radially outward in ducts F and in the casing In the generator there may be a radial channel for ea tooth which joins the casing with a longitudinal duct in the teeth. In the model these ducts are replaced by seamless 1-inch-external-diameter tubes bent to sen circles. The resistance to flow offered by the long gener tor duct was simulated in the model by resistance orific for each tube. The hood surrounding the 16 seamless es was put on solely to reduce the windage loss, which found, from wattmeter measurements, to be low.

he Discharge End. The left end of the generator's rotor ly is nearly similar to the right end, with the liquid ving radially inward to the hollow shaft *L*. After ving axially through *L*, the water flows radially outward ough symmetrically spaced holes *M*, terminating in the charge orifices located close to the outer shaft diameter. the model, a 12-inch-diameter cylinder was pressed on hollow shaft, as 12 inches is the shaft diameter needed transmit the torque for a large 3,600-rpm generator. r holes *M* in the model constitute a centrifugal pump, l they are the principal means for producing the flow liquid. Plugs were screwed into the cylinder adjacent its outer periphery with holes 7/32-inch in diameter, 0.15 square inch for all four. Without allowing for eam contraction, the velocity through these orifices is 3 feet per second at a cylinder peripheral velocity of 5 feet per second and yields a flow of 55 gallons per nute.

The Discharge Collecting Chamber. After discharge from orifices into the stationary inner collecting chamber some liquid passes through holes in the cylinder separat- the two collecting chambers. The remaining liquid sses between stationary ribs and the shaft (or the model's inch cylinder) into another inner collecting chamber , where under the action of the centrifugal forces from rings *X* most of this remainder is discharged through es into the outer collecting chamber. The liquid is ined from the outer collecting chamber to the sump ough drain 4, Figure 3. What little liquid is left should be carried to the sump through small drain 3 from which there was a trickle during operation. There are no rubbing seals. In the model the side plates are slightly smaller at their inner diameters than the 12-inch cylinder. It is suggested that, in a generator, the part of the shaft which is enclosed by the collecting chamber be slightly larger in diameter than the adjacent parts in order to compensate for the weakening which is due to the holes *M* and the holes for the orifice plugs.

During the passage of the liquid through the rotor the centrifugal action thereon between the hollow shaft and the rotor ducts at the right end is balanced substantially by that at the left end. However, the head generated in the discharge holes *M*, functioning as a centrifugal pump, is not balanced. Such head is considerable and appears largely as static pressure just below the discharge orifices where it is converted into velocity head.

The Catch Basin at the Inlet End. A nonmetallic ring, of such internal diameter that it clears the pipe *AB*, has been added. This decreased the leakage, and most of the water that got past the ring escaped from the catch basin through drain 1. The rotating ring between the two stationary discs serves to throw off the water, which is drained to the sump through drain 2. There was no external leakage, and there are no rubbing seals. No doubt the resistance offered by the outside of the stationary pipe *AB* and the inside of the rotating hollow shaft, causing the water to move in a spiral, also reduced the amount of liquid drained off.

Operation of the Hydraulic System. The setup is shown schematically in Figure 4. The water level in the elevated

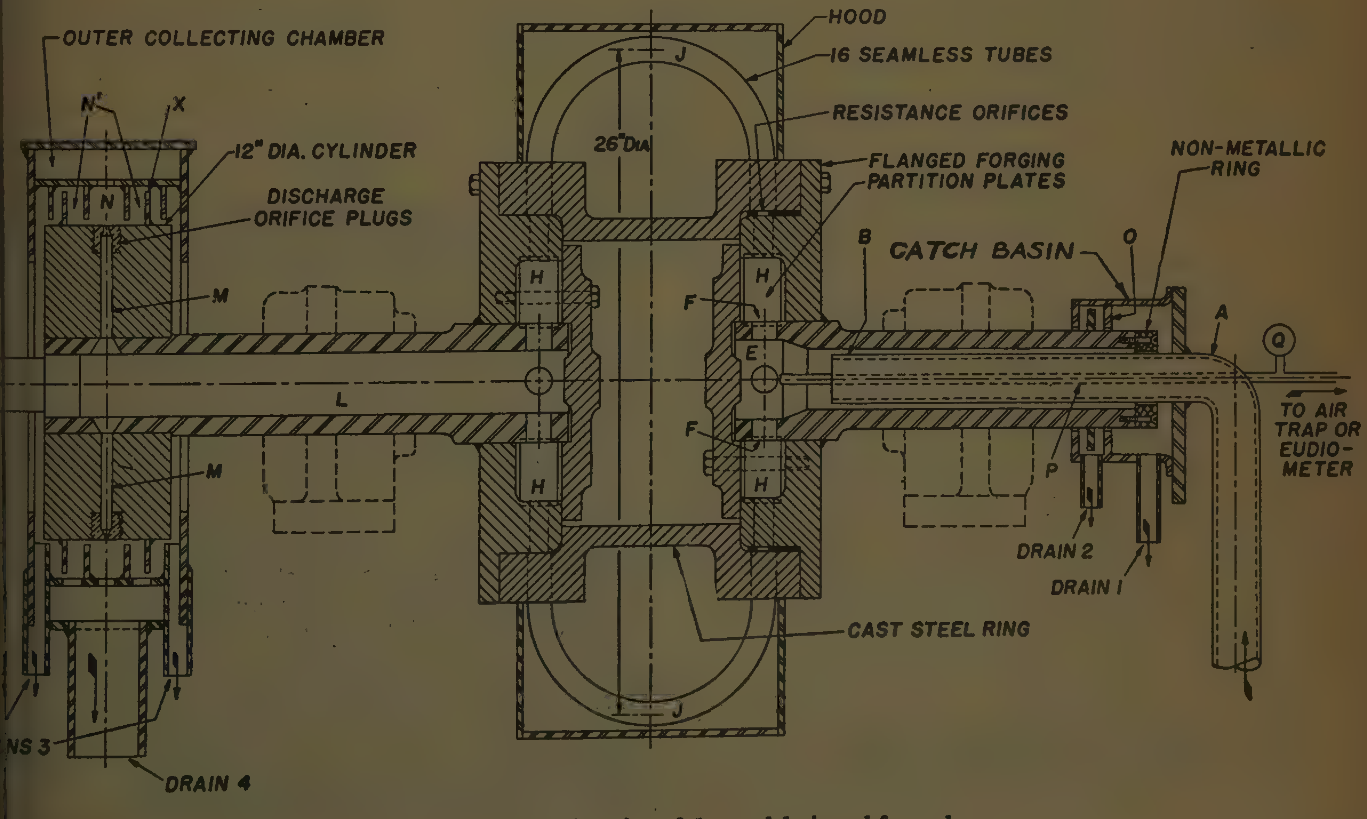

Figure 3. Longitudinal section of the model viewed from above

tank is only seven feet above the model's horizontal center line, and produced a pressure of about three pounds per square inch with the model at standstill and two pounds per square inch when running. The purpose of the elevated tank and sump is to secure two separately functioning systems which operate together in series in a closed system. Otherwise, with two centrifugal pumps in series there would be likelihood of surging.

When starting, valves 1 and 3 are closed and 2 is opened to prime the pump. Then 2 is closed, the pump is started, and valve 3 is partly opened to fill the tank, with the overflow assisting in maintaining the water levels. Then the model is turned over slowly by hand and valve 1 is opened. The model then is brought up to full speed, with valve 3 being opened sufficiently to keep the tank full.

At full speed the volume of flow is determined largely by the centrifugal head generated in the holes M. With the small inlet head and with loss of head between E and L, the pressure in the hollow shaft near discharge is probably below atmospheric pressure. It is conceivable that this reduced pressure might affect the volume of flow. The drops in pressure between entrance and the shaft bore L can be reduced by beveling or rounding the various ducts when the liquid enters them and by making the liquid rotate just before it leaves the enlargement E at an angular velocity approaching that of the shaft. One way of accomplishing this is to rifle the bore of the hollow shaft. Raising the tank level also would raise the absolute pressure in the shaft bore L.

Some air was absorbed by the water as it discharged from drain 4. The partition was included in the sump to preve air entering the small pump and causing it to lose priming. In a generator the drain pipes should be su merged; no partition then would be needed in the sum Bubbles rose at times in the eudiometer showing that t pipe P served a useful purpose.

Generator Rotor Losses and Water Temperature Rise. A cording to design calculations of a liquid-cooled generato rated 100,000 kva, 85-per cent power factor, 3-phas 3,600 rpm, with 0.81 short-circuit ratio, the total rot loss is about 334 kw, with 254-kw loss in the embedd parts. If 55 gallons of water per minute are to abso these 254 kw, the water temperature rise would be 17 degrees centigrade. The 80-kw loss in the coil ends wou be taken up by the circulation of hydrogen, as describ previously. The hydraulic losses, most of which are the internal centrifugal pump M, were found from measur ments with a polyphase wattmeter in the driving moto circuit of the model to be 11.7 kw, which would cause t water temperature to rise 0.8 degree centigrade mor These losses appear mostly after the water has absorb the rotor loss.

It may be desirable, in order to secure somewhat mo uniform temperatures longitudinally in the rotor copp in such a large generator, to reduce the water temperatu rise by increasing the rate of flow. To secure a shor circuit ratio of about 0.81 with the large number of ampe turns, a long air gap is necessary. The loss in the rot surface due to tufting of flux from the stator teeth is ve small. With a long air gap those stray losses (with balanc stator currents) appearing in t rotor surface are of little cons quence. Also, when operated in hydrogen atmosphere the winda is small, and much of that loss taken care of by the circulating h drogen. Therefore, the only loss considered as affecting the rot temperature rise have been losses the rotor winding. With the small ratings, for which an air atmosphe is proposed, conditions are simil to the large machines with hydroge

Mitigation of Coriolis' Forces. T Coriolis' acceleration is given by t vector $2(dr/dt)\omega$. For the liqui cooled rotor, dr/dt is the radial v locity of the liquid with respect the rotor, and ω is the angular v locity. Multiplied by the mass de ity, this acceleration then gives t force per unit volume of liqui With the relative flow in a radi direction, these forces are found be tangential.

If a small volume of liquid tur the corner at the entrance to t longitudinal ducts J, which h sharp corners, and then flo

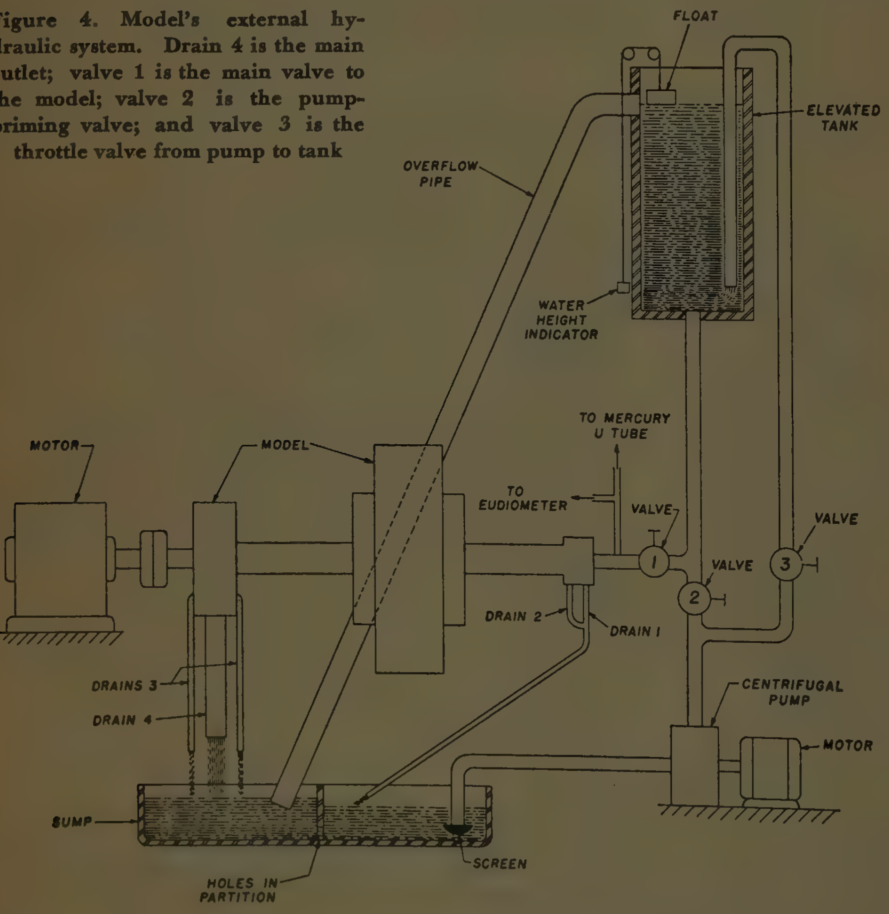

Figure 4. Model's external hydraulic system. Drain 4 is the main outlet; valve 1 is the main valve to the model; valve 2 is the pump-priming valve; and valve 3 is the throttle valve from pump to tank

ally, the velocity in the radial supply duct diminishes m the position at the bottom of the duct *J* to the . Unequal tangential Coriolis' forces are produced ich would cause the liquid to whirl just before entrance *J*. At the exit end the phenomenon would be similar, t the sense of rotation would be opposite. Such whirls uld obstruct the liquid flow.

n the model with the 16 curved tubes *J*, apparently the w was not impeded by such whirls, as the flow was large. idently, if each tube had a straight portion longitudinally ween two curved ends, there would not be any diminu- n in flow due to Coriolis' acceleration. Consequently an actual machine, if suitably curved tubes were used each end, the harmful effects of the whirls would be minated. As such tubes would probably be of rec- igular section (instead of circular, as in the model), d generally of unfavorable aspect ratios, they can con- niently be provided with curved guide vanes, as has been ind very beneficial for stationary elbows.[5] One of several table constructions is indicated in Figure 5.

Considering the casings *H*, on the side in which the uid flows outward as it leaves the holes *F*, it is moving space at the tangential velocity corresponding to the ter diameter of the holes *F*. As the liquid moves outward *H* its tangential velocity would have to increase if it is flow in radial paths (with respect to the rotor). The rtia (Coriolis) forces then would cause the liquid to fall ck, with respect to the rotor, and thereby to flow in cumferential paths in opposition to the direction of ation. With respect to outside space it would move in same direction as the rotor but with reduced angular ocity. As this circumferential flow would interfere iously with the desired radial flow, it is prevented by means of radial partition plates so that the liquid flows in radial paths (with respect to the rotor) as if there were radial ducts throughout.

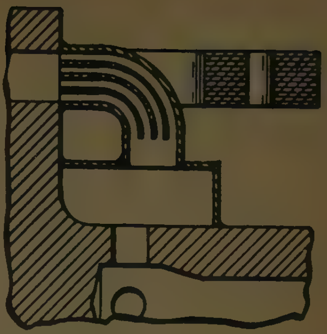

Figure 5. Section of rotor intake duct with guide vanes

On the return side the liquid flows radially inward, and the circumferential velocity tends to be more than that of the adjacent parts; that is, it moves at greater angular velocity in space than the rotor. Again partition plates are needed to prevent harmful circumferential flow.

When constraints cause the liquid to flow in prescribed paths, the Coriolis' forces produce pressure against the walls all the way from the bore of the hollow shaft to the outermost radius of the radial ducts. On the outgoing side they act against rotation and on the ingoing side with rotation; therefore torques are produced which substantially balance each other.

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Measuring the Sound of Fluorescent Lights

Noise output of fluorescent lights is being measured by a laboratory expert. Reducing this sound is an objective of designers of constant-wattage ballasts widely used in fluorescent lighting fixtures. The research program conducted by Sola Electric Company of Chicago, Ill., takes place in many parts of the plant, with lights in hallways, offices, and production areas. Time switches operate the lights automatically, turning them off and on according to a fixed schedule. The tests take place under normal business conditions, which make them more accurate indicators of what can be anticipated in lamp life and discoloration. A major part in the experiments concerns the part ballast plays in relation to these factors. A section of one corridor in the building is among the world's brightest spots. Dozens of fluorescent lights burn day and night in a small area. Automatic equipment turns them on and off, measures the period during which they burn, and counts the number of times they are snapped on, an important factor in lamp life. Groups of test fixtures also are installed in various places in the plant.

Corona Investigation on Extra-High-Voltag Lines—500-Kv Test Project

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IN A GROUP of papers[1–6] presented before the Institute in 1947, the subject of extra-high-voltage transmission lines was discussed and the need pointed out for additional information on corona and radio-influence effects before such lines could be built on a sound engineering and economical basis. One of these papers[2] outlined the field test research project which was being undertaken by the American Gas and Electric Company in co-operation with eight manufacturers of electric equipment to provide the much needed information on corona, radio influence, and other features.

The test site is located adjacent to the Tidd power plant. The test lines have been energized almost continuously for over three years and much valuable information has been obtained. It is the purpose of this article to present the high points and as much of the detail of this investigation as possible. This article will be confined almost wholly to the effects of corona, particularly on conductors; companion papers[8,9] cover the radio-influence aspects and measurement technique and equipment in detail.

Corona effects on extra-high-voltage lines have been investigated at the site of the Tidd power plant. In making these tests, the effects of voltage changes and various weather conditions on corona were observed.

GENERAL DESCRIPTION

ALTHOUGH a general description of the testing equipment and facilities at the Tidd site has been given previously,[2–6] a few of the high points of the facilities may be of interest here.

Three full-size test lines, two 1.4 miles and one 800 feet long, were constructed in the field and energized through a 5,000-kva bank of three single-phase transformers. A test voltage range from about 150 to 500 kv phase-to-phase can be obtained by transformer taps and by connecting the low-voltage windings in either delta or wye. Provision was made for varying the conductor spacing and ground wire height. The conductors[4] tested ranged in size up to 2.0 inches outside diameter and were of the steel-reinforced-aluminum-cable, copper Hedernheim, and copper I-beam types. Two-conductor bundles also were tested.

The towers are single circuit for flat configuration and liberally designed for flexibility in altering the test arran ments. They are the approximate general dimensi which might be used if a 500-kv line were to be built.

The instrumentation includes supersensitive indicati and recording wattmeters for measuring corona loss, a indicating and graphic instruments for determining rad influence effects. Other instruments consist of a pho graphic weather recording device, a ground gradient met and conventional instruments to record temperatu barometric pressure, and so forth. Special test setu were made to determine insulator losses and to simula conductor temperature rise due to load current.

Corona loss is obtained both on indicating instrume by so-called "manual tes and by graphic charts whi are operated continuous Manual tests are defined those where observations a made on indicating instr ments and recorded manual For manual tests the vo age is varied over the ran available in a relatively short time to obtain essentia constant weather conditions. For the graphic records t voltage is maintained constant for periods of several da or more.

GENERAL CONSIDERATIONS

THE CORONA LOSS of a particular single (as contrast with a bundle) conductor can be determined co pletely in terms of the "nominal gradient" at the surface given weather and surface conditions. Nominal gradi as defined here is that gradient that would exist at t surface if there were no corona present and the conduc were a perfect cylinder. In practical configurations t charges on other conductors have a negligible effect up the voltage gradient of the conductor under considerati the gradient being determined almost entirely by t charge upon itself. The configuration does affect t charge upon the respective conductors. For a giv configuration and voltage the charge and nominal gradi can be calculated by conventional means. For examp with a flat configuration the charge upon the center c ductor is about five per cent higher than the charges on outer conductors. For this reason the gradient at center conductor is correspondingly larger. Therefo the fundamental corona data in this paper are plotted terms of the nominal gradient as the parameter. Si nominal gradient is proportional to the charge on conductor and the charge in turn is proportional to

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Essentially full text of paper 51-12, "Corona Investigation on Extra-High-Voltage Lines—500-Kv Test Project of the American Gas and Electric Company," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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harging current, many of the curves have an additional cale showing this quantity. In many respects this is a more fundamental quantity than nominal gradient as it can be observed directly. To convert from current to nominal gradient the following conversion formula can be used:

$$G_n = 4404\frac{q}{r} = \frac{4404\,i}{2\pi f\,r} = 11.7\frac{i}{r}$$

in which G_n is nominal gradient in kilovolts per centimeter; q is charge in coulombs per mile; i is charging current in amperes per mile at 60 cycles; r is radius of conductor in inches; and f is frequency in cycles per second.

The authors make no apologies for the conglomeration of units. The English and metric units are interspersed because the critical value of G_n is usually expressed in kilovolts per centimeter. F. W. Peek, Jr.,[10] gives the crest value of the critical visual gradient as 40 kv per centimeter for conductors above one inch in diameter.

To orient the loss curves with practical line configurations the abscissae sometimes are plotted in terms of line-to-line voltage. Unless otherwise stated, a 32-foot flat spacing is assumed. Since these scales cannot be exact for all curves they are marked "approximate."

For bundle conductors the presence of the other conductors comprising the bundle produces a nonuniform field around the periphery. For a 2-conductor bundle, Francois Cahen[11] of France found that if a gradient equal to the mean of the maximum and average gradients were used the characteristics of a single conductor (multiplying by 2, of course) could be used to predetermine the characteristics of the bundle.

Unless the surface of a conductor is highly polished and the tests made under carefully controlled conditions, considerable variation results in the values of corona loss measurements. For practical transmission lines these conditions do not prevail, and it is essential that the loss be obtained on conductors as they are used in the field. Among the factors contributing to this variance and which were investigated are the following:

1. Normal variations in weather—fair, rain, fog, snow, and sleet.
2. Long-time surface aging of the conductors.
3. Short-time surface effects as the result of changes in the applied voltage.
4. Heating of the conductors by load current.
5. Electrostatic ground gradient.

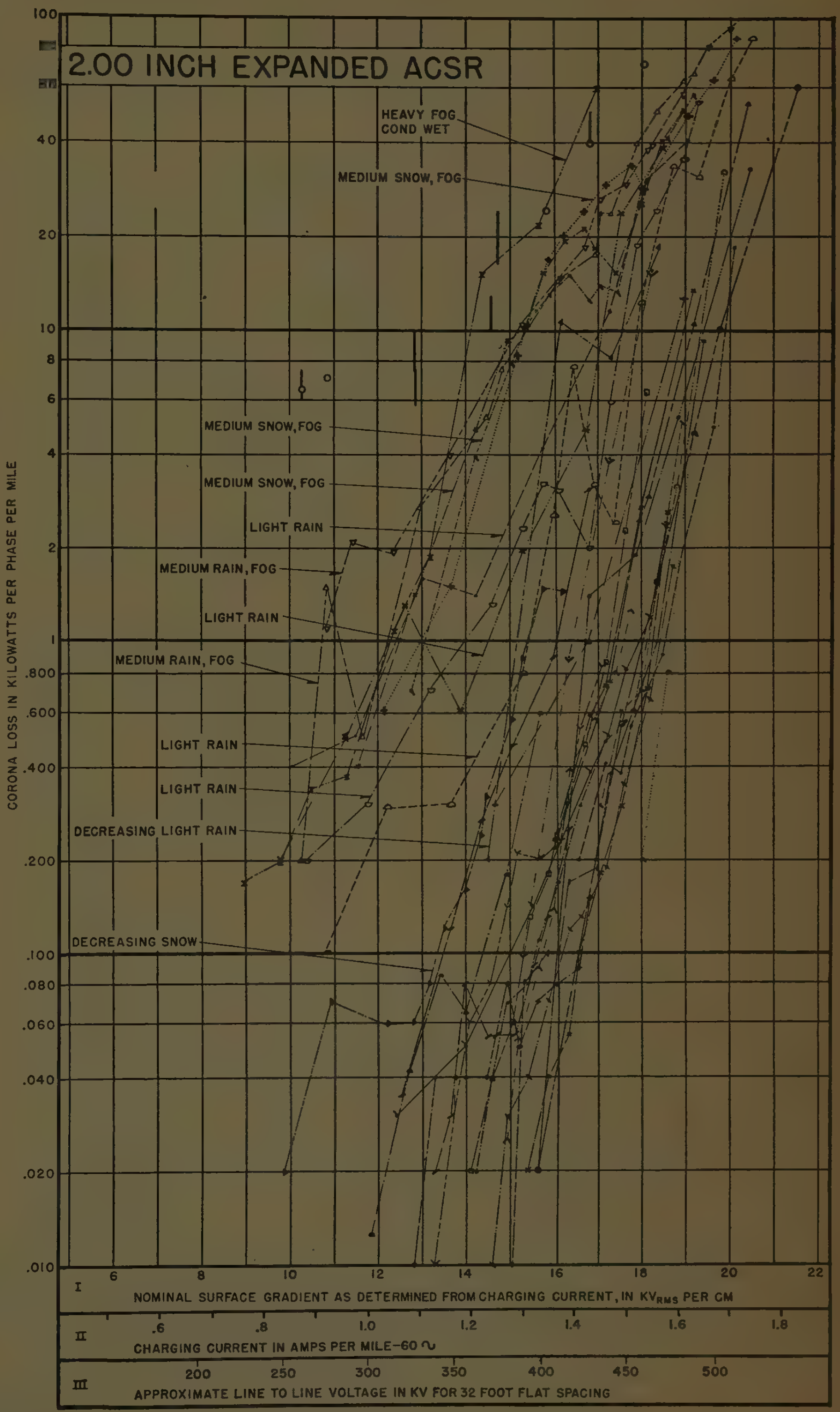

Figure 1. Corona loss on field test line for one of six conductors tested. Measurements made visually (manually). Unlabeled curves are fair-weather data. All curves corrected to an air density factor of 1.0

DEFINITIONS

Fair weather as defined here is a condition of no visual abnormalities such as rain, fog, snow, sleet, or smoke in the vicinity of the conductor. Foul weather refers to all other conditions. Since rain plays such an important role in corona phenomena, to co-ordinate the data taken at Tidd with conditions elsewhere in the country the data are presented in such form that they can be converted to other weather conditions by means of information available from the United States Weather Bureau. The Weather Bureau records provide no means for differentiation between fair and foul weather except on the basis of precipitation. The graphic record data therefore w divided into precipitation and apparent fair weath periods, the former being defined as such times duri which an indication of precipitation occurs on the r gauge at Tidd. Apparent fair weather then is, co versely, those periods in which no indications of precipi tion appear on the rain gauge. The more sensitive pho graphic recorder shows that there are times during whi the precipitation is so light that it does not indicate on t rain gauge. The photographic recorder also indica periods of fog and periods of moisture condensation on t conductors that would not be recorded as precipitati

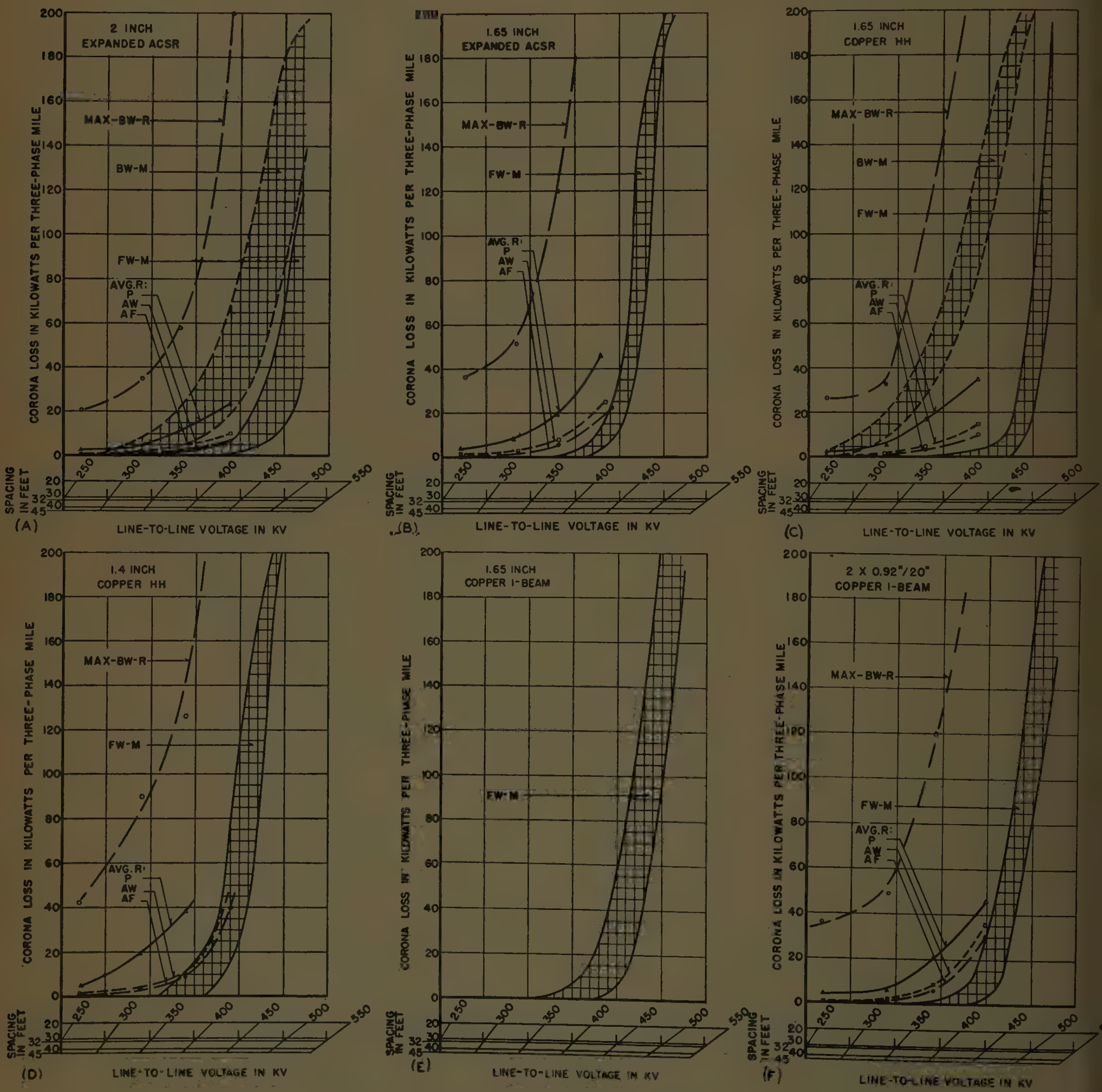

Figure 2. Corona loss variation for different conductors—fair and foul weather

M = Manual data
R = Recorded Data

P = Precipitation
BW = Foul Weather
AF = Apparent Average Fair Weather

FW = Fair Weather
AW = All Weather

eriods. All of these factors contribute to increased orona loss. It would be expected, then, that the loss luring the apparent fair weather period from the graphic harts would be higher than the loss during fair-weather ests obtained by manual observations, and the field tests onfirm this.

FAIR WEATHER LOSS

FIGURE 1 represents the corona loss as a function of voltage for short-time tests on one of the principal onductors tested during the investigation at Tidd. In ach case the conductor was voltage-seasoned just prior o testing in accordance with the technique described in nother paper.[9] Those curves not specifically marked therwise were made under fair weather conditions.

In spite of the seasoning process and the correction to tandard conditions, great variation in day-to-day results till remains. Other investigators have obtained similar esults. An attempt was made to determine the cause of hese variations without very definite conclusions. Some f the explanations considered are:

1. Dust or foreign particles adhering to the surface. The number and size of such particles might vary with the dhesive character of the surface film and with the electrostatic forces present when the conductor is energized.

2. Changes in the surface condition occasioned by hemical action of the atmosphere.

3. Changes in moisture content of the surface film on he conductors.

It will be noted from Figure 1, which shows a large umber of tests on a single conductor, that successive fair veather tests do not repeat, and that there is a large spread n the foul weather data. Thus, comparisons between onductors are difficult. Therefore Figure 2 has been prepared. The cross-hatched areas bounded by the full ines represent the zones in which the fair-weather curves all. The abscissa on each curve is arranged so that the oss can be determined for any phase spacing.

As mentioned previously, loss data also were obtained vith continuously recording charts. From indications on he rain gauge these records were divided into apparent air weather and precipitation periods. With the lines pperating at any given voltage, the losses for the apparent air weather periods were averaged arithmetically. The esults for these averages for different voltages and different onductors also are plotted in Figure 2. The test period or any given conductor and voltage varied between three nd ten months. Comparing these curves with the fair veather curves it will be observed that the losses are reater. This results from the definitions of fair and pparent fair weather; the loss for the latter condition ncluding loss during periods of fog, condensation of noisture on the conductors, and rain so light that it cannot be recorded on the rain gauge.

FOUL WEATHER CONDITIONS

BEFORE discussing the effects of foul weather it might be well to consider its importance and the means vailable for gauging and interpreting its magnitude in terms of conditions applying to practical systems. Corona losses under foul weather are so much greater than the fair weather values that recognition of them must be given in capitalizing the losses of transmission lines. Some form of average, taking all types of weather into consideration, must be used to this end. Peak values also might be of importance in very special cases in determining whether extra generating capacity might be required to carry the additional load during storm conditions.

Foul weather encompasses all adverse weather conditions, such as rain, fog, snow, sleet, and so forth. Of these the major contributions to foul weather loss occur during rain. Furthermore, the records of foul weather which are available from the United States Weather Bureau are most complete for rain, and, in addition, contain a factor to include snow and sleet in terms of equivalent rain. Thus, rain appears to be the best single parameter to characterize the additional losses occurring during foul weather.

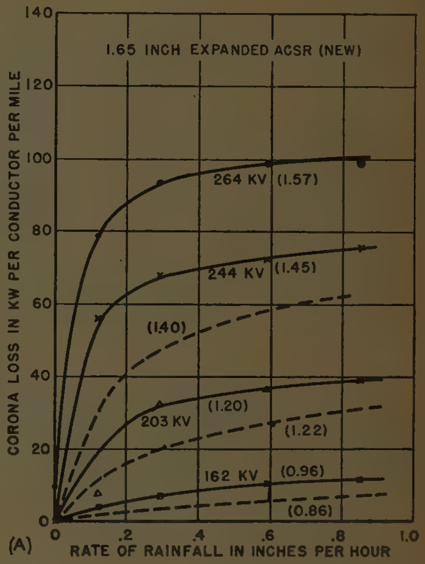

Figure 3. Effect of continuous uniform rainfall. Full lines for Trafford Laboratory tests. Voltage on each curve is the voltage to the ground plane. Dotted curves are field data for the same conductor after aging. The numbers in parentheses are the amperes per mile at 60 cycles

FOUL WEATHER LOSS

Laboratory Data. Field tests under foul weather conditions, such as rain, snow, sleet, and fog, offer innumerable difficulties, largely because the conditions do not remain constant. It was to obviate these limitations that laboratory tests were made. Artificial rain can be obtained in the laboratory at controlled rates. Figure 3 shows the loss at different voltages as a function of the intensity of rainfall for one conductor. The dry values of loss are plotted as zero rainfall. It will be observed that the range between dry and rain conditions is dependent upon the voltage. A characteristic of these curves is that above about 0.2 inch per hour a definite flattening occurs. Similar data taken from field tests over 5-minute intervals during which the rain was essentially constant are drawn in dotted lines.

To throw some light on the nature of the phenomena that occur during rain conditions, laboratory data showing the loss on a new 1.65-inch steel-reinforced aluminum cable after stoppage of rain are plotted in Figure 4 as a function of time. It can be seen that the loss decreased suddenly from 40 kw per mile to 30 kw per mile and thereafter gradually along a somewhat exponential curve to its final value. The sudden drop might be due to absence of drops of water falling near the surface but not striking it. These drops of water produce points of ionization and loss either because of their already small radii or because of the formation of small radii by distortion. Another possible explanation of the sudden change is the cessation of splashing of the drops as they hit the surface. Perhaps during rain some of the loss can be attributed to the electrostatic repellent action of charged droplets leaving the conductor. The slow change is probably due to the evaporation of water from the surface.

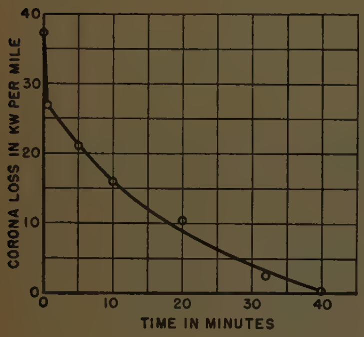

Figure 4. Corona loss after stoppage of rain. Initial rain is 0.75 inch per hour. Rain stopped at zero time. Single 1.65-inch expanded steel-reinforced aluminum conductor, 203 kv to ground plane

Field Data. Atmospheric conditions fluctuate so greatly during foul weather that it is difficult to obtain a voltage run which will plot as a smooth curve. A large number of such tests were, however, made under a variety of conditions and are plotted in Figure 1. Each curve is marked in accordance with the prevailing weather. A large number of such tests are necessary to establish a relation between fair and foul characteristics. The general bands which were covered by foul weather conditions are plotted in Figure 2 for the 2-inch expanded steel-reinforced aluminum cable and the 1.65-inch Hedernheim conductors.

To illustrate the probable upper limit of corona loss under adverse conditions, the curves marked *Max-BW-R* have been plotted on Figure 2. These are instantaneous values which are the maximum values of the losses as recorded on the graphic charts for the entire period covered by these tests. It must be borne in mind, however, that these figures apply only to a line 1.4 miles long. Rain storms of the intensity that give rise to these peak values are limited in area and would not cover an entire transmission line at one time.

The curves of Figure 2 marked *P* (precipitation) give the average recorded loss during precipitation. Because of the definition of precipitation used in these tests, the values indicated might be lower than the average value during periods of actual rain. By definition, precipitation covers not only periods of actual rainfall, as indicated by the rain gauge, but also those periods before and after an indicated period of rain during which loss apparently attributable to rain occurs. In spite of the long period of time which was covered by the tests these curves are n strictly comparative as they do not always cover simul neous periods.

Of most significance is the effect of rain and all weath upon the average loss for the year. The all-weather curv in Figure 2 are the averages over very long periods a include fair weather, rain, fog, snow, and sleet, in oth words, all weather conditions experienced during the ye These values apply, of course, for the particular location which they were obtained, Brilliant, Ohio. They mig be different for other locations where the proportion foul weather is different. In an effort to convert the da to a more useful form so that they can be more universa applied, the results were expressed in terms of inches rain per year—a value that can be obtained for practica any location in the country. These results are plotted Figure 5 for four of the commonly used kinds of conducto These curves were obtained by choosing operating peric varying in duration from two to ten days and averagi both the loss and the precipitation for each period. E tremes of adverse weather were avoided intentionally wi the purpose of attaining a precipitation distribution th approximated actual annual distributions.

The data of Figure 5 are one of the important e products of this investigation. The authors believe th data in this form are the most practical in which to app the information. By reference to the annual rainfall f the territory through which the line will be run, avera annual corona loss can be predicted easily.

Energized conductors undergo both a short- and a lon time aging. The former phenomenon has been discuss in another paper[9] because it is vitally concerned wi testing technique and is not important in the applicati of the conductor. The latter phenomenon is discuss here as it has an important bearing on the corona chara teristics. Figure 6 shows the loss of a conductor as function of time as observed from voltage runs taken fr time to time. It will be observed that the loss requir about six months to eventually stabilize. Upon t limited evidence which was available at the time, copp appears to possess greater aging characteristics than alun num.

HEATING OF CONDUCTOR

CONTINUOUS CORONA tests on short unloaded li exposed to the weather differ in one respect whi might have an important bearing on the results. Sin only a very small current flows in the line, the rise temperature above ambient is negligible. On a line service the load current is usually sufficiently high so th the copper loss produces a temperature rise of 5 to degrees centigrade above ambient. Any object, p ticularly a good radiator, in the absence of radiation fr the sun will acquire a temperature below ambient a therefore will condense moisture during periods of hi humidity. Thus, condensation is more likely to occur the case of the test conductor than on an actual line service.

In order to test this hypothesis, a local current was ma to flow in the steel core and return in the aluminum stra f one of the steel-reinforced conductors, which would raise he temperature about 8 degrees centigrade. At the time he article was submitted for publication the data from these ests had not been analyzed adequately, except to know hat the effect was significant.

GROUND GRADIENT

IT HAS BEEN suggested[2] that electrostatic ground gradient due to harges in clouds might affect the orona loss as a result of the induced harge in the conductors. To test his hypothesis a special ground radient instrument[15] was designed nd built, which could record coninuously the variation in ground radient on a chart. However, the esults obtained from use of this nstrument indicate no apparent ffect.

CORONA ON HARDWARE AND FITTING

IN THE DESIGN of the test setup, special consideration was given o eliminating corona and other efects from what might be called acessories to the conductor, that is, nsulators, shielding line-hardware, nd shielding points such as susension or dead-end clamps, tap onnections, and so forth.

Without grading shields at 374 v, no corona was observable on the nsulator strings even down to 20 nits. At 427 kv, slight corona ppeared on insulators up to 30 nits. At 500 kv and without hields, corona was observed up to 4 units.

Limited field visual observation when the lines were energized inicated no corona problems would e encountered on conductor hardware such as dead-end conductor lamps, conductor splices, and tap onnections, which would be of maor concern if suitable grading shields were used on the line end of insulaor strings.

CONCLUSIONS

1. Great variations in conductor orona loss result from weather conitions, rain and fog raising the oss considerably above fair weather alues. In the practical range of xtra-high-voltage lines, conductor izes, and conductor spacing which now being considered, the maximum corona loss may be as high as 40 to 80 kw or more per 3-phase mile during rain, while the fair weather loss may be about 1 kw or less.

2. With increasing rates of rainfall the corona loss for a given conductor at any given voltage increases, but at a

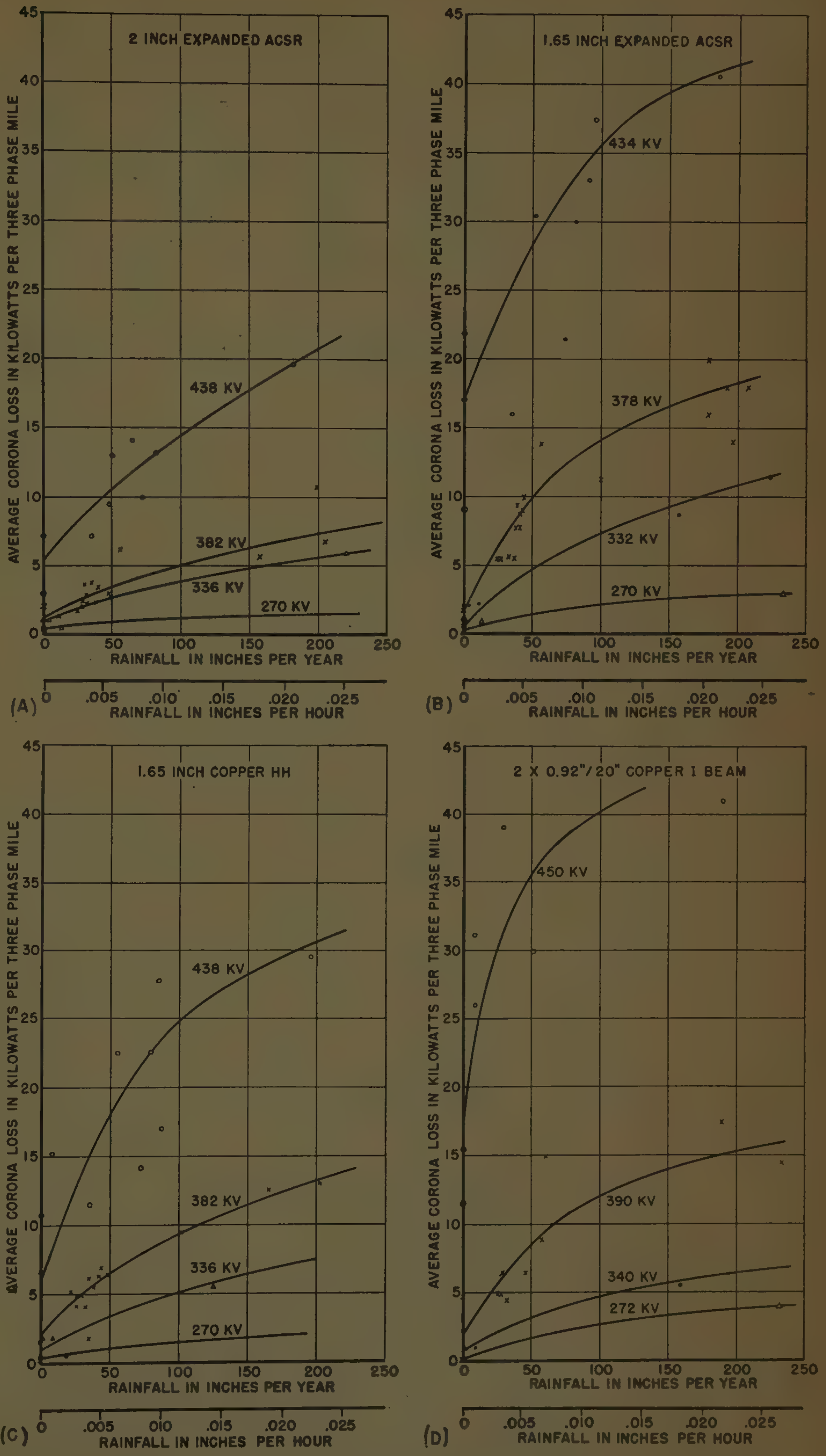

Figure 5. Effect of rainfall for all weather on the field test lines for different voltages. Both the loss and precipitation were averaged over periods of several months including both precipitation and fair weather periods. The numbers on the curves are line-to-line voltages for 32-foot flat spacing

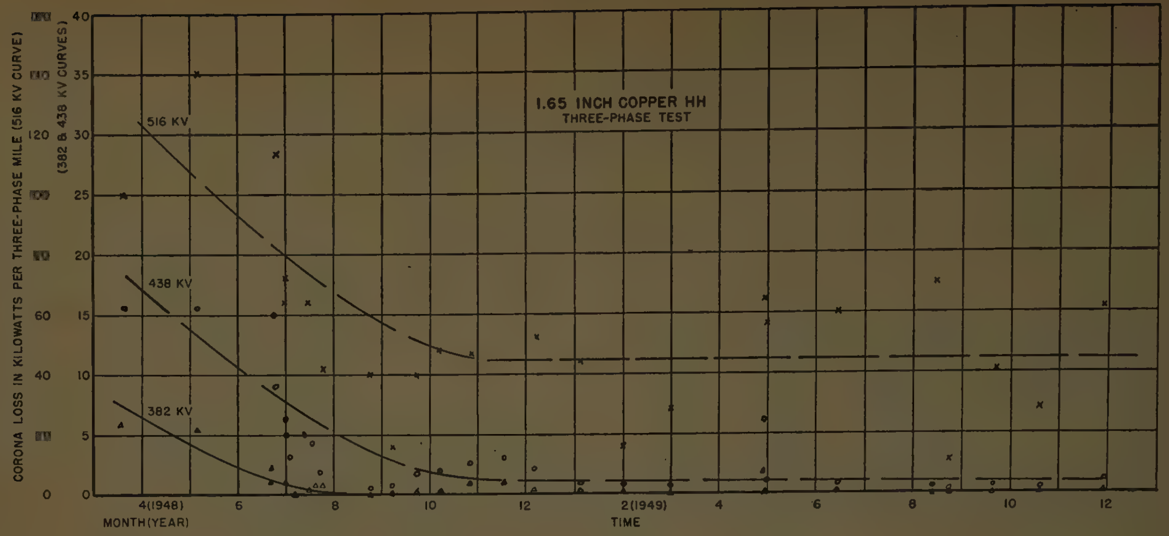

Figure 6. Typical long-time weathering curve. The numbers on the curves are line-to-line voltage

less rapid rate than the rain, tending to become constant at very high rates of rainfall.

3. Corona losses under wet and stormy conditions are of much greater importance economically than fair weather losses.

4. Determination of annual corona losses on a line can be made using the data presented here when correlated with Weather Bureau records in the location where a transmission line is contemplated.

5. Corona loss during foul weather which blankets an extra-high-voltage system may be sufficiently high as to require additional installed system generating capacity to supply the loss.

6. The aging or weathering of conductors requires from six months to a year to bring the initially high loss down to a comparatively stable lower value.

7. The surface potential gradient on the center conductor of a line of flat configuration exceeds by about 5 per cent that on either outside conductor.

8. The measured charging current (an index of the conductor surface gradient) is about 5 per cent higher than the calculated values determined from physical dimensions. This should be recognized when detailed calculations are made to predetermine corona performance of a conductor.

9. Ground voltage gradient appears to have a minor effect upon corona losses, although a study of this phenomenon should be continued.

10. Radio influence begins when corona loss is still immeasurable but increases at a lower rate than corona.

11. The presence of two ground wires on a line of flat configuration has no significant practical influence on the conductor corona loss.

12. The copper loss (I^2R) of a conductor in service raises the temperature sufficiently to prevent condensation of moisture during fog, with a resultant decrease in corona loss. Consequently, corona losses reported here for all weather and foggy weather are higher than will occur in service.

13. The corona loss performance of conductors shoul take into consideration not only the fair weather los but also the all-weather and storm weather loss which ar of more significance from an economic loss point of view.

14. The data presented here, it is believed, provide th basic information for making a sound engineering choic of conductors for an extra-high-voltage system, if used i conjunction with other important considerations in regar to the conductor and the economic influence it has on given line.

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Community Dial Office Equipment

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Equipment for community dial offices which serve small or sparsely settled communities is described in this article. The discussion covers service features, equipment features, and maintenance facilities.

COMMUNITY dial central office equipment is presently used as entral office equipment erving exchanges which vary n size from a few lines to everal hundred lines. The equipment is usually located at a point some distance rom traffic and plant department personnel and must operate satisfactorily unattended except for routine visits of service men. The equipment should provide all the necessary services required in its service area. It should be reasonable in first cost and low in maintenance. It should be compact in size so that a minimum of building space is required, yet it should be easily accessible for maintenance. It is desirable that it be readily expandable o care for growth and for the addition of service features.

Community dial offices are telephone central offices of the dial switching type that are designed particularly for small communities. They are distinguished by relatively small size, by a preponderance of multiparty lines, by equipment assemblies designed for quick installation at remote points, and by maintenance features to facilitate unattended operation with a high grade of service.

Low cost is an important objective in the design of community dial offices because they frequently serve sparsely settled areas where it is difficult to furnish adequate telephone service at reasonable costs. However, the offices described here are designed for providing all service features that may be desired by the customers at a reasonable cost.

Many community dial offices serve less than 100 subscriber lines. Other offices serve up to a thousand or more lines. Larger offices generally are considered outside of the community dial category, although in many cases their features may be essentially the same.

SERVICE FEATURES

General. The service features required for community dial offices vary from location to location, depending upon size of the office and its proximity to larger centers of population. However, these service features may be divided into two general classifications: (1) those required in all offices, and (2) those required for the particular installation in question.

Multiparty Lines. Provision must be made in all cases for serving lines on a multiparty basis and, in general, equipment capable of serving lines having eight or ten parties per line will be adequate. However, in certain areas it may be necessary that the equipment be arranged to handle lines serving up to 20 parties each. In smaller community dial offices individual, 2-party, and 4-party lines are handled as unfilled multiparty lines. Provision may also be made for handling a small group of lines on a consecutive line hunting basis. In addition to these lines which are arranged for flat-rate service, it usually is necessary to serve coin stations. In most community dial offices these lines are served on a post payment basis, that is, deposit of coins after answer of the called party or upon request by the operator.

Uniform Audible Signals. In order that telephone users throughout the country may be able to dial calls in a uniform manner, it is necessary that audible signals be uniform. The first of these audible signals which the user will encounter is dial tone, which tells him the equipment is ready for him to begin dialing. The time interval between removing the receiver from the telephone to application of dial tone should be as short as possible to reduce to a minimum the probability of mutilated dialing. When the calling party has been connected to another line or to a trunk to an operator, he should receive an audible ringing indication to satisfy him that the called party or operator is being signaled. If the user encounters a busy condition, he should receive the busy signal. The busy signal is a tone of the same fundamental frequency as dial tone but it is interrupted 60 times per minute. The length of the tone intervals and silent intervals are 0.5 second each.

Reverting Call Arrangements. Reverting call arrangements must be provided to enable stations on the same line to call each other. Where the exchange is equipped for bridged or divided code ringing, reverting calls may be made by the calling subscriber. First he dials the listed directory number of the desired station on his line. Upon completion of dialing the busy tone will be returned. The calling subscriber then hangs up, and the central office equipment tests to determine if the calling and called lines are the same. If so, the called code is rung. If the line is arranged for divided ringing, a reverting ring one-half second in length will be rung on the opposite side of the line during each half of the ringing cycle. When ringing is tripped by the answer of the called party, the calling party may lift his receiver and begin the conversation.

In offices arranged to serve multiparty lines on a semiselective or full selective basis, reverting call selector circuits must be provided. These circuits usually are reached

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Full text of paper 50-249, "General Aspects of Community Dial Office Equipment," recommended by the AIEE Committee on Communication Switching Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950. Published in AIEE *Transactions*, volume 69, part II, 1950, pages 1540–3.

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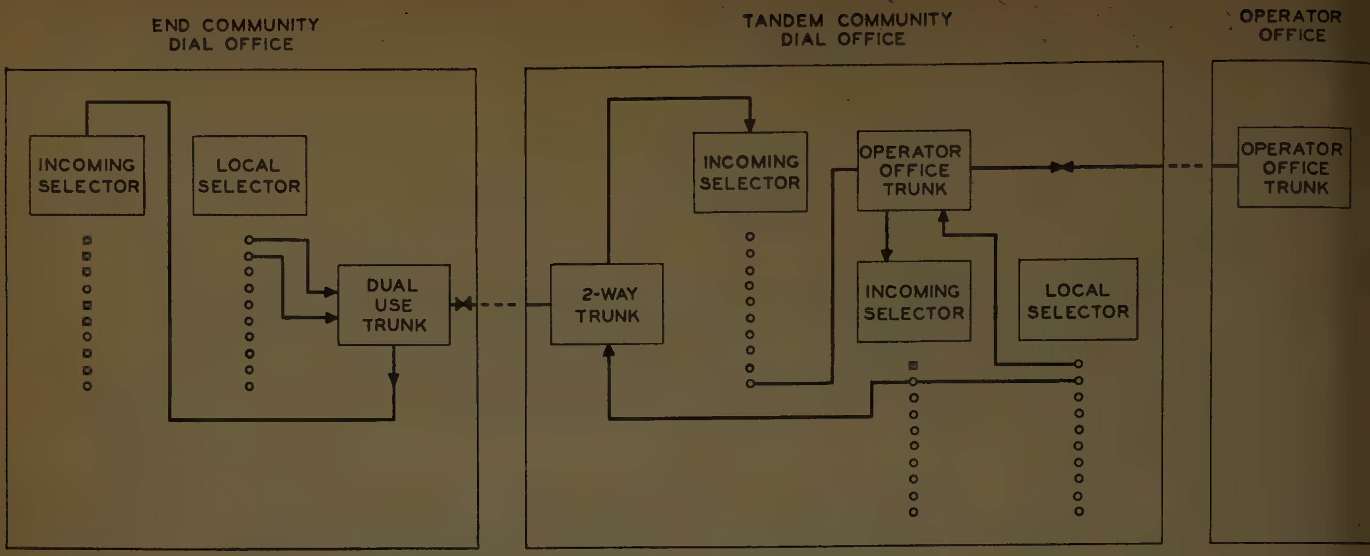

Figure 1. Tandem trunking arrangement for access by subscribers to operator only

from a selector level of first selectors or their equivalent. In offices equipped with reverting call selectors, the calling party must dial an arbitrary number rather than the listed directory number to reach another station on his line. Otherwise the method of operation by the subscriber is essentially the same as for the directory number method.

Operator Office Trunks. Trunks for handling traffic to the operator office are reached by dialing 0 and are usually arranged for 2-way operation. In order that the trunks may be used with various types of outside plant facilities it is necessary that they be available for loop, composite, or simplex signaling operation. Since they are used in common by flat-rate and coin subscribers, facilities are provided so that the operator may know when coin stations originate the calls so she may request deposit of coins. This is usually done by having a short spurt of dial tone sound when the operator answers. It is desirable that the equipment be arranged so the operator may check for this tone by pulling down the cord and replugging.

Under some conditions it may be desirable to route traffic from a community dial office through another community dial office used as a tandem center. For this arrangement the trunks from a tandem center to the operator office are as described in preceding paragraphs. The trunks between the end community dial office and the tandem point may be arranged for access to the operator office only, as shown in Figure 1, or for dual use as trunks to the operator office and as dial trunks for completing calls between subscribers at the end office and the tandem office, as shown in Figure 2. In either case subscribers at the end community dial office should reach the operator by dialing a single digit 0. When the trunk is arranged to reach the operator office only, the dialing of the digit 0 causes the community dial office equipment to select a trunk to tandem. At the tandem office the trunk is connected automatically to one of the common groups of operator trunks without the need of extra digits. If the trunk is arranged for traffic both to the operator and to the tandem office, the community dial office equipment selects the trunks to tandem when the subscriber dials 0 and then the trunk automatically sends a digit 1 to the tandem equipment. This digit causes a trunk to be selected to the operator office. If the trunk is used for a call terminating in the tandem office, a digit other than 0 is used to select the trunk, and then the regular listed directory number i dialed for completing the call.

In areas served by several community dial offices which reach the operator office through a tandem point, and where there is a toll charge for calls between offices, a shown in Figure 1, it is sometimes desirable to use dial-back-type operator office trunks between the tandem office and the operator office. Dial-back operator office trunks are trunks over which an operator may receive an incoming call from a community dial office and complete it by dialing back over the same trunk to subscribers in the community dial office where the trunk terminates, or via that community dial office to subscribers in a dial exchange beyond. This type of trunk may be desirable where excessive backhaul would otherwise be involved. In general, trunks of this type have disadvantages from an operating viewpoint for use with an operator office employing a large toll board because the supervision is different from that on regular operator office trunks. However, there may be cases where avoidance of long backhaul would result in appreciable savings.

There are two general types of dial-back trunks: (1) The simple dial-back trunk is the type where the calling subscriber holds the line while the operator dials back ove the same trunk to reach the called party. (2) The dual dial-back trunk functions similarly to the simple dial-back trunk but also allows the operator to complete calls on a delayed basis. To complete a delayed call the operato first dials the calling party and upon answer she proceed to dial the called party over the same trunk. These trunk require circuits at the operator office which permit dialing back against either on-hook or off-hook supervision.

Stop-Dial Signals. Trunks from operators which terminate on line circuits or for other reasons are not prepare to receive dial pulses upon seizure should be arranged t give a stop-dial signal. This signal consists of an off-hoo condition which should persist from immediately after seizure to the time the trunk is in condition to receive pulses. The stop-dial signal functions to stop operators or mechanical senders from pulsing to trunks before the circuits have conditioned themselves to receive pulses.

Flashing Supervision to Operators. All circuits which complete calls from toll operators should be arranged to give the originating operator flashing supervision when a line-busy or trunk-busy condition is encountered. The speed of flashing for line busy is 60 interruptions per minute with tone and for trunks busy is 120 interruptions per minute without tone.

Control of the Connection. On calls between subscribers in the same exchange, the calling party usually has control of the connection. On calls from a subscriber to an operator, the connection should be controlled jointly by subscriber and operator after answer by the operator. This arrangement permits the subscriber to flash the operator and also allows the operator to change cords, if necessary, without losing the connection. On calls from the operator to a community dial office subscriber the operator usually controls the connection. This arrangement allows the subscriber to flash but prevents him from holding a trunk out of service if he fails to hang up.

Traffic Registers. Traffic registers are provided to determine the amount of traffic handled by the office and to determine if calls are being lost due to insufficient equipment. The following registers are usually provided:

1. Peg-count register per finder group.
2. All-finders-busy register per finder group.
3. Peg-count register per incoming selector group.
4. All-trunks-busy register per trunk group.
5. All-trunks-busy register for reverting call selectors.
6. Peg-count register per connector or final group.

Terminal-per-Line versus Terminal-per-Station Service. Smaller community dial offices in rural areas are nearly always arranged to serve subscribers on a terminal-per-line basis. This makes a system economical in the amount of required terminating equipment. However, some flexibility is sacrificed, and the problem of providing intercept service, if required, is made more difficult and costly. In areas where these features may be required, it is desirable to serve subscribers on a terminal-per-station basis. This is usually the case in offices exceeding roughly 500 lines in ultimate size and in all offices, regardless of size, which are located near metropolitan areas.

Transmission Balance. At present with the expanding use of electrical services in the rural areas it is essential that transmission circuits be as carefully balanced as possible to avoid noise caused by inductive interference. It is necessary to have the subscriber lines balanced as well as possible, but it is also necessary that all central office terminations connected to these lines be balanced.

Community dial offices frequently have to be arranged to give services that are not uniformly required in all offices. The most commonly encountered of these services are verification, intercepting, and message-rate line circuits.

Verification. It is desirable that verification arrangements be provided where possible, particularly in offices near metropolitan centers, in order that emergency calls may be completed to busy lines. These facilities also permit verification of a line-busy condition. In community dial offices verification calls are usually completed through the regular switch train by the operator dialing a preliminary or supplementary code in addition to the subscriber's number. Verification facilities should be available to operators only. Wherever verification facilities are provided they should permit a uniform method of operation with all the community dial offices involved.

Intercepting Service. Intercepting facilities are not ordinarily provided in offices of less than 500 lines unless the offices are adjacent to metropolitan areas, because of the cost of this type of equipment. In offices not equipped with intercept facilities, final terminals should not be made busy nor return the audible ringing signal to calling subscribers or operators, since these signals would be false

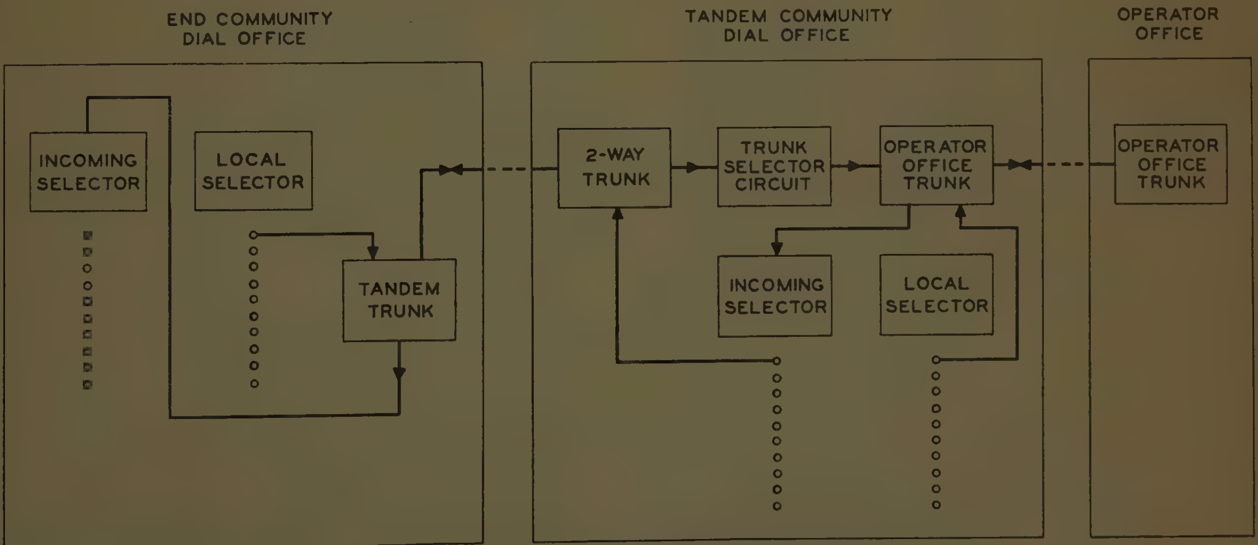

Figure 2. Tandem trunking arrangement with dual use trunks

indications. If intercept facilities are not used, it is desirable that the equipment be arranged so that no signal is returned on the call.

Message-Rate Service. In some cases it may be necessary to serve a few lines on an individual line message-rate basis. This usually is accomplished by the addition of an auxiliary circuit ahead of the regular line circuit. The auxiliary circuit operates the subscriber message register upon answer of the called party. To prevent improper operation of the circuit due to surges, a delay interval of two to four seconds is usually provided between the answer and the actual application of the charge condition.

EQUIPMENT FEATURES

Simplified Installation. It is desirable that community dial equipment be designed to permit the maximum amount of wiring and cabling at the factory. This reduces installation time on the job. The equipment may be arranged in unitized packages; these packages are to be of such dimensions and weight that they will be handled easily in shipment and transported through standard-sized doors. For the very small offices, it may be possible to have the equipment for the entire office mounted on one such frame. For larger offices several frames may be required. Although it is desirable to have the equipment frames as small and compact as possible, care should be exercised to prevent crowding of apparatus making maintenance difficult. The total weight of the frame should not exceed reasonable permissible floor loading limits.

Adequate Traffic Capacity. The design of the frames should allow for an adequate number of switching paths to care for expected growth in lines and traffic. Although the initial installation may not require the frame or frames to be fully equipped, the ability to add circuit units as required as economically as possible is desirable. This may be accomplished by the use of units connected by jacks.

Standard Floor Plan. Installations requiring two or more frames usually are arranged in accordance with an acceptable floor plan. Their location with respect to the distributing frame and power plant should permit short runs of cable. The distributing frame should provide space for an adequate number of protectors and be arranged to permit easy access for changing cross connections for subscriber moves and disconnects. The battery-charging plant should have ample capacity to maintain the battery in a charged condition during the busy-hour load. The storage battery should have ample reserve capacity to protect against office failure during times of commercial power stoppages. The necessary reserve for an office is usually determined by estimating reliability of commercial power service and will vary in different areas.

MAINTENANCE FACILITIES

Alarms. Since community dial office equipment is unattended, means may be provided to supervise the operating condition of the office. This is accomplished by providing a final terminal as an alarm-checking terminal. Whenever this terminal is dialed by the distant operator or maintenance man, the presence of tones or lack of tone

Table I. Alarm Signals

Alarms	Time Before Transmission of Alarm, Minutes	Signal on Checking Termina
Major Alarms		
Main and common fuses blown	0	No tone
Ringing failure	1 to 4	No tone
Low or high voltage	1 to 4	No tone
Master charge control relays	1 to 4	No tone
Line finders blocked	1 to 4	No tone
Excessive Number of Permanents	0	Dial tone
Minor Alarms		
Individual fuses blown	0	Busy tone
Ringing transfer	1 to 4	Busy tone
Release magnet	1 to 4	Busy tone
Permanent Signals Less Than Excess Number	20 to 60	1-ring code
No Trouble		2-ring code

indicates the condition of the office. In addition to th alarm-checking terminal, an alarm sender is usually provided. When a trouble condition occurs at the community dial office the alarm sender seizes a regular trunk to the operator office. When the operator answers, no special indication of the trouble is given. It appears as an abandoned call except the cord supervisory lamp remain dark and the trunk does not release until the alarm checking terminal has been dialed. The operator dial the number of the alarm-checking terminal over anothe trunk and receives a tone signal indicating the class o alarm. The dialing of the alarm-checking terminal als releases the trunk used by the alarm sender. Wher trunks are arranged for dial-back operation, the operato dials the alarm-checking terminal back over the sam trunk over which the alarm signal was received. Whe an alarm sender is not used the operator must dial th alarm-checking terminal periodically to determine if trouble condition exists.

The signals of Table I usually are used to indicate th class of alarm when the alarm-checking terminal is called

General Maintenance Facilities. As stated before, eas access to all apparatus greatly facilitates maintenance In many cases most routine tests and maintenance operations will be performed by personnel who spend only a par of their time working with central office equipment Therefore, it is important that testing procedures be a simple and straightforward as possible. Most of thes tests can be in the nature of operational tests. Th circuits employed in community dial offices should b simple and the use of marginal operating arrangement avoided where possible. Simple make-busy arrangement should be provided to hold out of service circuits which ar in trouble. In general, fewer common circuits and relatively simple circuit design will result in easier maintenance

Community dial office equipment should be designe to furnish all the necessary services required with th minimum maintenance attention. The circuit arrangements should be simple and easily understandable. Th equipment should be rugged in design in order to be suitable for operation in buildings which will have a minimun of heating in winter, yet not be affected by high summe temperatures. It is desirable that expansion requir a minimum of engineering and installation work.

Small Dial Telephone Central Office Buildings

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BECAUSE of increasing costs, the design of dial telephone central office buildings for small communities is being scrutinized by most telephone operating companies with the object of specifying the most economical type of construction consistent with the requirements. The general building design features are determined chiefly by the type of community and the climate, while the detailed design is governed by the housing requirements of the dial equipment.

The type of building under study is one designed for a small telephone central office to house dial equipment varying in size from 100 to 1,000 subscriber lines. In such an office, the telephone users pass calls requiring operator handling by dialing to an operator in a nearby manually operated central office, so no operating or maintenance personnel are in attendance in the building. These buildings are 1-story structures having floor dimensions varying in size from 8 by 12 feet to 25 by 28 feet, as required by the number of subscriber lines which are to be served.

The general design is controlled by such factors as the size of the building, the type of community, the prominence of the building site in the community, and the climatic conditions anticipated. These factors may necessitate a more expensive treatment of the design in such matters as decoration and architectural styling. The possibility of control of cost is sometimes limited as a result. Selection of a site on a secondary rather than a primary street will often aid in minimizing the building costs.

The special design features, which depend on the housing requirements of the equipment, include such factors as resistance to fire, floor loading, control of temperature, and control of moisture.

Where serious exposure to fire hazards exists, full masonry construction is often employed. However, where the fire hazard is normal, a frame building with fire-resistant asbestos siding will usually be adequate and less costly than masonry.

Floor loadings of 125 to 150 pounds per square foot, together with the need of a vibration-free base for the equipment, usually indicate the need for a reinforced-concrete floor slab. Vibration-proof construction is required wherever excessive vibration from trains or heavy machinery is to be expected.

Heating may be required for the comfort and convenience of maintenance personnel during their periodic visits. However, these installations are normally nonattended, and a normal temperature during cold weather of 10 to 40 degrees above 0 degrees Fahrenheit will frequently be sufficient. To avoid the possibility of explosive fumes or introduction of water vapor into the building, electric heat is preferred over any type of fuel. To control the cost of electric heating, adequate insulation should be provided and a rather low constant temperature maintained. Under favorable conditions, and using ceiling-mounted electric radiant heating panels, an annual heating cost of $30 to $40 is estimated for a 5-month heating season in the Chicago area. This cost would naturally vary with climatic conditions.

Fixtures requiring plumbing should be avoided because of the likelihood of the water freezing during very cold weather.

To avoid excessive summer temperatures, ventilators are often provided, but these should be arranged so that they can be closed in winter, especially if electrical heating is to be provided.

Control of moisture is important because of the possibility of cabling or wiring absorbing moisture with resultant lowering of the insulation resistance. Waterproofing of the floor slab or raising it above ground on footings will prevent water seepage through the floor. Ventilation is effective at some locations in preventing moisture condensation.

At stations in very humid locations chemical dehydrators have been employed, but the disposal of the corrosive residue is generally a problem. Electric dehumidifiers are now available in small sizes, but they are not generally used because of anticipated high operating costs. At most locations, tight closure of doors or other wall openings, supplemented if necessary by small ventilators for summer use, are considered adequate for all normally encountered conditions.

For a building designed for an office having such limited revenues as to make the control of cost a primary consideration, there is a variety of typical designs which have been used by various companies. Prefabricated construction of either wood or metal offers some promise but, at present, there appears to be no prefabricated building design which would be adaptable to general application. While many companies have used masonry designs, it does not appear feasible to adapt this type of building to low-cost fabrication because of the relatively high costs of materials required and because nearly all of the building trades are represented in the labor requirements and usually have to be transported to a more or less remote location. Labor costs of a masonry building are often twice the cost of the construction material.

Several companies have reported the successful use of frame construction applying conventional wood frame and asbestos or asphalt shingle siding and roofing. This type of construction is probably the best compromise design in cases where revenues are limited so that cost must be kept at a minimum.

Digest of paper 50-248, "Dial Telephone Central Office Buildings for Small Communities," recommended by the AIEE Committee on Communication Switching Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

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Operational Study of a Highway Mobile Telephone System

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The problem of interference of nearby stations was one of the greatest problems which had to be overcome to permit the satisfactory use of mobile telephone service. This article tells of a study made of the interference encountered on one highway mobile telephone system and the measures made to counteract it.

SUBSTANTIAL progress has been made during the past few years in establishing mobile telephone service for vehicles. This service, inaugurated in St. Louis, Mo., on June 17, 1946, is given through two types of systems. Urban mobile telephone systems serve the metropolitan areas and many of the cities of 100,000 population and over, and highway mobile telephone systems serve intercity highways, waterways, and cities along these routes which do not have independent urban facilities. These highway systems have been rapidly expanding into large area coverage systems blanketing complete states. The urban mobile telephone systems operate on channels in the 152- to 162-megacycle band, while the highway systems have been allocated channels in the 30- to 44-megacycle band.

As of May 31, 1950, highway mobile telephone service in the United States has expanded to include 110 base transmitting stations, serving about 3,500 mobile units and handling approximately 81,000 completed calls per month. These highway systems already cover many major highways in both the East and the West. In the Middle West, state-wide coverage systems have been established in Michigan, Wisconsin, Minnesota, Illinois, Missouri, Kansas, Oklahoma, Arkansas, and Texas. Existing highway service base stations in the United States are shown on Figure 1.

When highway service was first inaugurated in Green Bay, Wis., August 28, 1946, it was planned to operate all stations throughout the United States on a single channel of two frequencies, one for transmission to the mobile unit and the other for transmission from the mobile unit. This would allow a vehicle equipped with the normal single-channel radio set to travel anywhere in continental United States and make or receive calls. During the testing of these systems, however, considerable sky-wave interference was experienced between systems separated geographically by more than 1,000 miles. A study of the situation indicated that the most satisfactory method for reducing this interference would be to use different frequencies in different parts of the country. Therefore the country was divided into zones 800 to 1,200 miles in extent and a particular pair of channel frequencies was assigned to each for its exclusive use. A frequency zoning plan comprising seven zones was adopted and is shown on Figure 2. With this plan all stations within a particular zone operate on the same channel frequencies. Vehicles moving from one zone to anothe may be equipped with an additional oscillator unit wit relay-switched crystals, which is controlled by a manua channel selector mounted beside the unit holding the handset. As the mobile subscriber moves into a different zon he must manually switch the frequency of his mobile radi equipment. Areas such as St. Louis, Mo., and Buffalo N. Y., located on zon boundaries, have base station operating on the channel frequencies of each zone. The channel switch mounted o the right side of the handse holder, as shown in Figure 3 is capable of manual switching to as many as six different channels in the highwa service band of frequencies The added oscillator and crystal unit serving both the transmitter and receiver is shown at the left of the radio transmitter in Figure 4.

The provision of highway mobile telephone service presented problems of considerably greater complexity than di urban mobile service. One important difference is th need for continuous coverage over the entire length o hundreds and, ultimately, thousands of miles of highway, o thousands of square miles of area, as against coverage of limited urban or metropolitan area. This, of course, requires many base stations established miles apart along th highway or covering the desired area. Each of these bas stations is operated as a separate entity with a particula point of contact with the land wire telephone plant, bu also each must function smoothly as a part of the whole system so that a mobile unit may travel anywhere in the entir service area and yet be reached promptly and satisfactorily. Operation on a single channel within a given zon complicates the problem of complete coverage of an area It is obvious that, to provide complete and continuou radio coverage of a highway or area, there must be areas overlapping coverage.

Full text of paper **51-7**, "Operational Study of a Highway Mobile Telephone System, recommended by the AIEE Committee on Radio Communications Systems and a proved by the AIEE Technical Program Committee for presentation at the AIE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled f publication in AIEE *Transactions*, volume 70, 1951.

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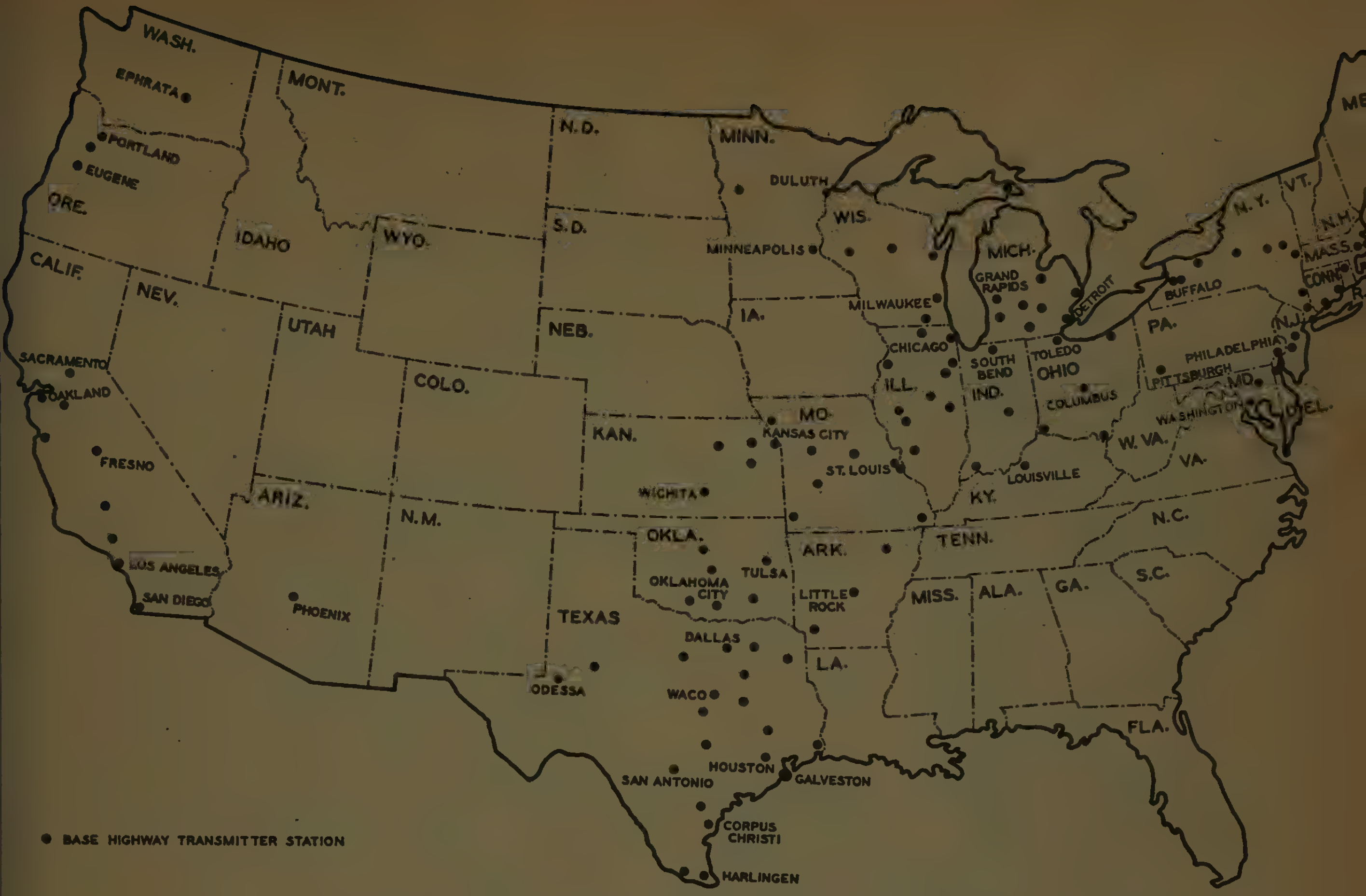


Figure 1. Base stations of the highway mobile telephone service

Consider, for example, the two adjacent base stations *A* and *B* with transmitters and receivers disposed as shown in Figure 5*A*. The irregular line surrounding each station is the boundary of the radio coverage area. A portion of the highway is covered by both stations. With both stations on the same channel, as is the case in highway telephone systems, a large portion of the overlapping area becomes an area of interference any time both stations are on the air. Now consider Figure 5*B* with vehicles at *X* and *Y*. Since neither vehicle is in the overlap area both could operate at the same time, *X* with station *A*, and *Y* with station *B*. Consider one further step shown in Figure 5*C*. Here a vehicle is located at *X* in the overlap area of the two stations. When *X* attempts to make a call it will no doubt bring in both operators because its transmitter opens the squelch circuits and operates signalling relays in receivers associated with both stations. One operator will handle the call, but each time the mobile unit at *X* operates its transmitter, it will bring in the other operator, giving her a false signal. Should the operator at *B* set up a call in her own area, operation of the *B* base transmitter in all probability will cause interference to mobile unit *X* receiving transmission from base transmitter *A*.

This difficulty was recognized at the outset, so to prevent all probability of causing interference between adjacent areas it was decided to keep station *B* off the air whenever station *A* was handling a call and vice versa. This was accomplished by providing the operator at each base station with a busy lamp, which lighted whenever the adjacent area base transmitter was on the air. When this lamp was lighted, the operators were instructed not to handle any calls through their stations. This became known as the "*A* On—*B* Off" method of operation. While this method did theoretically prevent all interference, should the mobile unit happen to be in the overlap area of two adjacent stations, Figure 5*C*, it also prevented many calls from being placed in situations like that shown in Figure 5*B*. This delayed many calls and reduced the traffic handling capacity of the system materially, since whenever one base station was on, adjacent stations to the right and left were artificially busy.

It was evident that when the linear systems developed into area coverage systems, the use of this method of operation would become seriously inefficient in the use of the radio channel and station equipment available. For example, in Oklahoma there are a total of six stations located at Enid, Tulsa, Oklahoma City, McAlester, Ardmore, and Lawton. In effect, five of them surround Oklahoma City and their coverage areas overlap that of Oklahoma City. Therefore, if the "*A* On—*B* Off" method of operation were used, each time Oklahoma City handled a call to a mobile unit all the other surrounding overlapping stations would have to keep their transmitters off the air. This would mean that one call in the Oklahoma City station area could prevent the handling of any other calls in an area of about 58,000 square miles, practically the rest of the state of

Oklahoma. This, of course, would not be efficient use of equipment or radio channel space and would result in poor service.

This was most provoking to the radio systems engineer, especially since it was more than likely that the particular call deactivating this tremendous area would originate from a vehicle in the center of Oklahoma City and the operation of any or all of the other base stations in the state would cause no interference.

Ideas for solving this problem ranged from a few high-powered transmitters with their antennas on very high towers covering large areas to low-powered transceivers located every quarter-mile and connected through an elaborate network of land wire to complex switching arrangements which would follow the vehicle from transceiver to transceiver. Most of the ideas were ruled out as being uneconomical for application to present systems, or as having a too limited traffic capacity. Information and experience as to the calling habits of highway telephone customers and the detailed functioning of the new systems under service conditions was needed for proper evaluation of these proposals. This kind of information is generally available to the designers, the traffic engineers, and operating method people of fixed telephone systems, based on years of study of the calling habits of the telephone user. While the necessary information on mobile systems based on experience would in time become available, it was agreed that much could be gained if somehow the gathering of the necessary information could be accelerated to a point where it would become available to all those interested in months rather than years.

The answer appeared to lie in a detailed operational study of a large working system. The Illinois state-wide Highway Telephone System was chosen for the study, since it was the oldest in point of service, the busiest, gave a typical example since it had both land and water vehicles with average spacing of base transmitter locations, and it included Chicago, the second largest city in the country and a city having a large confluence of road and waterway systems. The layout and coverage areas of this system ar shown on Figure 6.

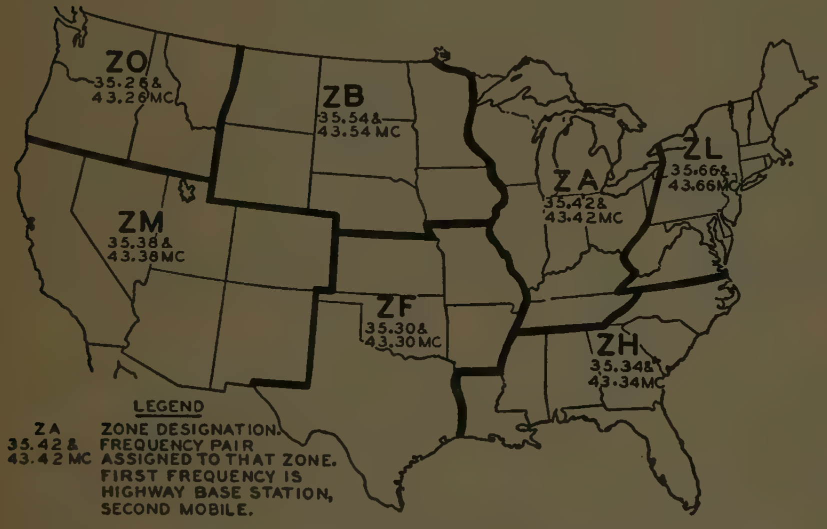


Figure 2. Frequency zoning plan for highway mobile telephone service

The main objectives of the study were:

1. To learn as much as possible about the genera operation and equipment functioning relationships of large mobile telephone system.
2. To evolve the most efficient traffic operating method
3. To learn something of the telephone habits of mobil service customers.
4. To determine what relation, if any, there might b between the density of vehicular traffic and mobile telephone traffic.
5. To determine the need for additional equipment o new practices to improve the service.

Trained observers with specially built observing equipment were located at each of the seven base operating locations. The equipment had lamps, a clock, and a monitoring circuit whereby the observer could follow and time th operations of the mobile service operator. It also containe a stop clock and two lamps associated with each base receiver by which the observer could record which base receivers were activated and the period each receiver wa selected for use by the base station receiver selector. B monitoring the radio channel she could record the telephone number of the called and calling customers, comment of these customers on their service, their location, an whether or not the call encountered any interference Lamps also kept her informed of the busy status of th adjacent areas.

During the study a provisional operating method wa used; it was designed to handle calls in area adjacent to a busy area provided the vehicl in the busy area was not in the overlap area The method was based on the premise tha if a mobile unit was in the overlap area i would be in range of base receivers of both areas and both operators should be able t hear the mobile unit each time it operate its transmitter. Normally the answer of th mobile service operator to a received signa on the radio channel causes the base transmitter to be activated. However, wher the mobile unit may be in the overlap area it was desirable that only one transmitte be operated in order to avoid interference Therefore, if an operator received a channel signal during a period when the adjacen area was busy (adjacent area busy lam lighted), she had to determine, before activating her transmitter, whether the signa was from a unit in her own area or from a operating unit in the adjacent area. To d this she had to be able to monitor her base receive without activating her transmitter. This was readily accomplished by providing her with a monitoring jack which gave her access to all her receivers, and throug which she could monitor whichever receiver was activate by a mobile call.

By monitoring the receivers, she could determine if the djacent area mobile unit was in range of her station. If he heard conversation, the provisional practice instructed er to leave a switchboard cord in the monitoring jack until he adjacent area call was completed, thereby preventing a ew signal (false signal) each time the mobile unit transnitted.

If the speaker heard no conversation after a reasonable eriod of monitoring, she could assume her signal did not riginate from the adjacent area unit, but from one in her wn area. Since the adjacent area unit was not then ctivating any of her receivers, she could further assume it vas not in the overlap area. Therefore she was instructed o plug a switchboard cord into the line jack, place her base ransmitter on the air, and proceed with the call. In the '*A* On—*B* Off'' method of operation this call would not ave been delayed until the adjacent area became idle and he busy lamp went out.

The mobile service operators also were instructed to andle outgoing calls to mobile units regardless of whether r not the adjacent area was busy. This was done on the ssumption that if a mobile unit operating in the adjacent rea was in the overlap area of the two base transmitters, it vould have brought in a line lamp and the operator would ave a switchboard cord in the monitoring jack. Thereore, no call could be handled without interference to the djacent area call.

With the "*A* On—*B* Off" method no interference beween calls in adjacent areas could occur since this condiion was nonexistent; however, under the provisional nethod, since calls were concurrent in adjacent areas under he conditions described, interference would occur at times ecause of changes in the position of the mobile units in the djacent areas after the calls are initiated.

While the provisional operating method required the perator to monitor on all incoming calls during periods hen the adjacent area was busy, it saved operating effort n preventing many false signals and showed promise of ncreased efficiency. Since a change in operating method nvolved no added development or equipment and could be pplied with relative ease and economy, the efficiency of the perating method which was used in the study was exmined first.

In the following paragraphs where interference is indiated, in so far as possible it refers to adjacent area interfernce. It does not always mean that detrimental interfernce actually occurred, but only indicates that it could have aken place. Interference, as considered here, ranged from he momentary selection of a base-receiver during a period vhen the local mobile unit was listening, which could be the ocal customer depressing his push-to-talk button while stening, to those cases where the conversation from the djacent area unit "captured" the base receiver from the ocal unit, thus interrupting his conversation.

During the period of the study, approximately 6,800 ompleted calls were observed. Of these, 3,400, or 50 per ent, were initiated during periods when one or more of the djacent areas were busy. This means that there was a 100 er cent increase in the number of messages handled withut long delay. Under the "*A* On—*B* Off" method, these messages would have encountered serious delay or might not have been handled at all.

A sample analysis of a typical hour for the whole system indicated that there would have been insufficient channel time at each station, when all adjacent stations were idle, to carry the traffic actually handled, even if the calls were timed to follow one after the other. Completing calls without long delays gives a greatly improved service which could not otherwise be realized without providing an additional channel at each station. In one station, Ottawa, surrounded by four other stations, as many as 74 per cent of the messages were handled during an adjacent-area-busy condition.

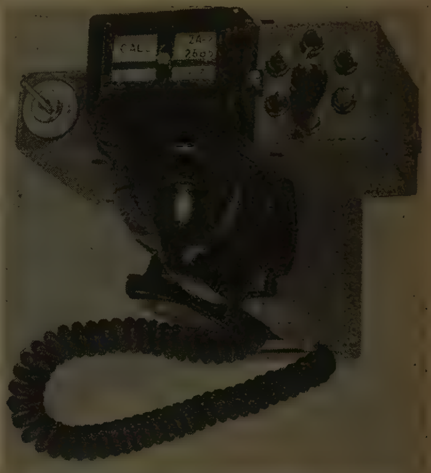


Figure 3. Mobile telephone control unit with channel selector mounted at the right

Figure 4. Multi-frequency highway mobile telephone equipment. Oscillator and crystal unit at left

As expected, some interference did take place. For the period of the study this amounted to about 3 per cent of the total 6,800 completed calls observed. During the first three weeks of the study period, before the operators were thoroughly familiar with the new practice, interference was noted on 4.3 per cent of the completed calls. During the last three weeks this figure had fallen to 1.5 per cent. It is expected that with well-trained operators the amount of interference in areas similar to Illinois should be between 1 and 2 per cent.

In the Chicago area the percentage of interference was comparatively high, 8.5 per cent, and showed little improvement with time as did the other areas. In order to ascertain as definitely as possible the cause of this, a special analysis of the Chicago area was made. Each case of interference was arbitrarily placed into one of three categories as to degree.

First degree. Interference causing a definite interruption, or one where comments were made by the customers.

Second degree. Interference where adjacent area conversa-

Table I. Summary of Possible Causes of Interference

Cause	Per Cent of Total
Operating Irregularities	.19
Range of Receiver Beyond Transmitter Range	.75
5,000 East End (South)	9.0
Munster (Southeast)	1.5
Lockport (Southwest)	42.0
Wheaton (West)	4.5
Lake Forest (North)	18.0
Miscellaneous	6

tion was heard but did not interrupt the call, or if noticed by the customers it was not commented upon.

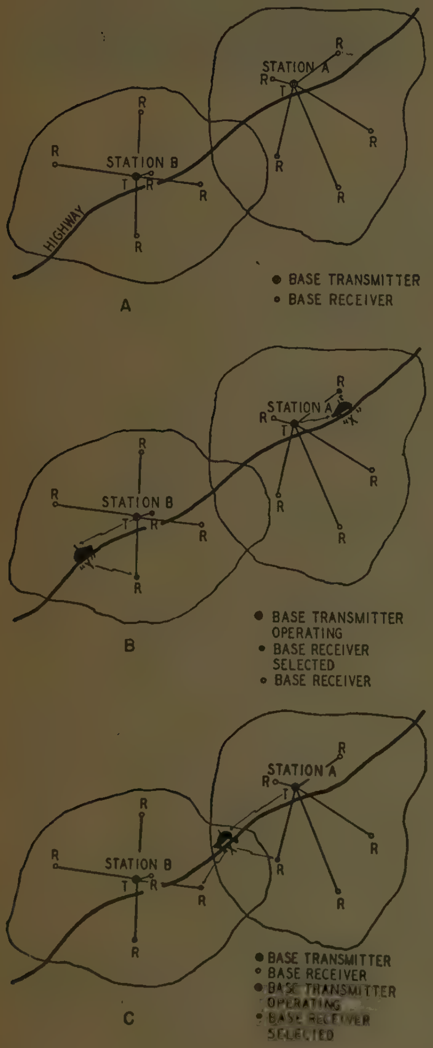
Third degree. Momentary selection of a base receiver presumably by a mobile unit in the adjacent area.

It was found that 31 per cent of the cases of interference were of first-degree nature, 51 per cent second-degree, and 18 per cent third-degree. This indicates that about one-third of the cases of interference recorded were serious enough to cause comment or stop the call. Possibly not more than one-half of all cases recorded would be noticed by the customers.

What were the probable causes of interference? Again the Chicago cases were analyzed with the result shown in Table I.

The excess in range of the base receivers to that of the base transmitter caused 75 per cent of the interferenc One receiver, Lockport, located in the southwest corner the Chicago transmitter coverage area to fill a receiv "hole" in an important area, was the largest single contri utor of interference (42 per cent). Its location, unfo tunately, caused it to have a deep coverage in the Ottaw area. This condition was aggravated by the fact that th general area is one of heavy traffic density because of cal from river-craft on the Chicago Sanitary and Ship Can and the Calumet-Sag Channel. While the Lake Forest r ceiver contributed 18 per cent of all causes, examination the data showed it was caused in a large part by the lack the adjacent-area-busy lamp associated with the Milwa kee area to the north, which was being installed during th study period.

Operating irregularities, mainly due to unfamiliari with the new method, accounted for 19 per cent of th interference cases. In large areas like Chicago, more di ferent operators are involved than in the smaller center and the introduction of a new method always requires mor time to reach full operating proficiency. It was found however, that all mobile service operators needed som special instruction in the physical functioning of a radi system to better understand conditions that arise and ho to handle them.



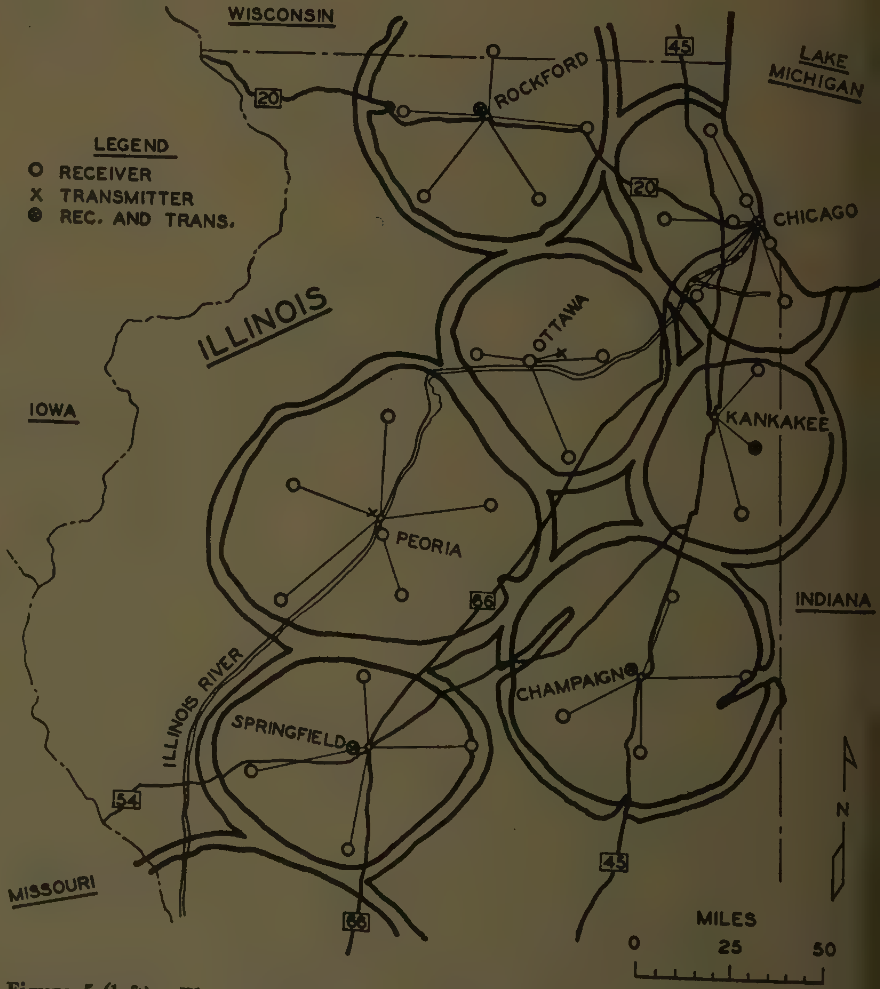


Figure 5 (left). Elementary highway mobile telephone service coverage map illu trating interference problems. Figure 6 (right). Illinois highway mobile telephon system and coverage map

A miscellaneous 6 per cent of the interference cases reulted from causes such as the adjacent-area test transmiters, used for testing and checking the base receivers, reachng beyond their own area; mobile customers momentarily lepressing their transmit button while listening (this is ictually not adjacent-area interference but only appears to oe); and probably some long-range interference from disant points in the same zone. The latter were eliminated rom the data whenever they were recognized.

The relation of vehicle density to mobile telephone traffic vas explored by a study of the mobile unit location and reeiver-used data. Referring to the system layout of Figure 6 and considering all areas, it was found that approximately 60 per cent of the mobile service traffic was handled through the base receiver located in the major city (base transmitter location) of each area, except in the case of Ottawa where only 19 per cent of the traffic was handled by the base receiver located in Ottawa. The major cities also represented the highest concentration of road traffic. In the case of the Ottawa area, the Illinois river provided most of the traffic, and the calls were spread between the three base receivers along the river. A high percentage of the Chicago traffic was also handled on the Lockport receiver for the same reason. Considering distance from the base transmitter, about 75 per cent of the calls were within a 15-mile radius, with about 80 per cent within a 20-mile radius, except for Ottawa where only 50 per cent were within 20 miles.

It is believed the success of the operating method used is directly related to the fact that a high percentage of the calls occur within a 20-mile radius of the base transmitter. While the number of areas studied was too small to be conclusive, it appeared that the percentage of interference rouble at any station was directly associated with the percentage of traffic beyond the 20-mile radius in a system where the base stations were approximately 50 miles apart. In Figure 7 are plotted points for four areas showing the elation of the percentage of total messages encountering djacent-area interference to the percentage of the total nessages occurring beyond a 20-mile radius from the base ransmitter. The dotted line indicates the trend, showing n increase in adjacent-area interference as the percentage of calls beyond the 20-mile radius increases. Of course, if he base transmitters were closer together than 50 miles, hese figures would not hold for the 20-mile radius but would pply to a lesser radius which, like the 20-mile radius in this tudy, would lie well away from the overlap areas of the djacent stations.

As a result of this study the following conclusions were eached.

1. It was decided to adopt the new operating method, vhich allowed calls to be made during adjacent-area-busy onditions provided the adjacent-area mobile unit was not vithin the range of any of the base receivers, since it proided a ready and economical means of increasing the effiiency of use of the mobile system equipment and channel pace. While it increased the interference over the old nethod from a theoretical zero to 1 to 2 per cent, it inreased the call-carrying capacity by as much as 100 per cent, thereby decreasing the delays encountered and improving the over-all service to the customer.

Soon after the introduction of this method to the new York–Buffalo Highway system in 1949, it showed a 10 per cent decrease in delays on traffic to the mobile units, while at the same time the total traffic on the channel increased 20 per cent.

2. For good system operation base receivers should be so engineered and maintained that their location and adjustment provides a coverage area which does not extend beyond that of the base transmitter. When attempting to handle simultaneous calls in adjacent areas this requirement is of even greater importance. It aids in preventing adjacent-area interference and improves service by making it impossible for the mobile customer to signal an operator who cannot reach him, causing an apparent "does not answer" to the customer and a "false" signal to the operator. While too much emphasis cannot be placed on this conclusion, in all fairness to the field engineer who is charged with laying out these systems it should be pointed out that this objective is difficult to realize in practice. This is especially true in flat country, where the transmitter and receiver coverages are approximately circular. Filling a transmitter circle with receiver circles cannot be done without either excessive receiver coverage or triangular holes around the transmitter fringe.

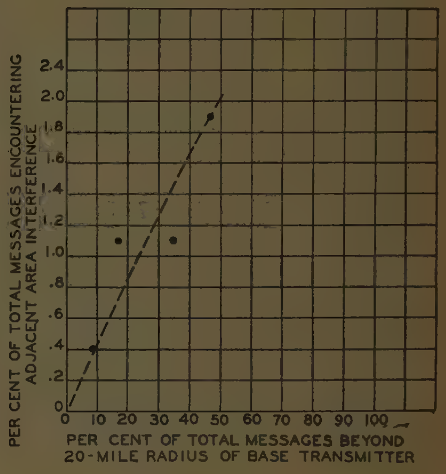


Figure 7. Relation between expected interference in any base station and percentage of completed calls made in outlying portions of its coverage area

However, this should not prevent the field engineer from doing the best possible job of covering all important areas within the transmitter circle, without excessive receiver coverage in the adjacent areas. Development work toward better solutions of this problem is still under way. The provision of an adjustable output test transmitter is a real aid in the maintenance of base receiver adjustments. With it, receiver adjustment can be easily checked at frequent intervals and the test transmitter can also be kept from reaching into the adjacent area causing interference.

3. Further education of customers, maintenance forces, and installers was necessary to prevent interference and undesired radiation from mobile units.

4. All operators should receive special instruction for mobile service work to better cope with irregularities which arise due to vicissitudes of the radio system.

Development and Operation of Small-Diameter Submergible Pumps

JOE CARLE

Submergible pumps with diameters from five to eight inches and lengths up to 28 feet are being used to pump oil and water from deep oil wells. These units are being used to pump volumes as great as 15,000 barrels of fluid during one day.

AS THE OIL industry developed from early days of shallow wells and "pitcher" pumps, the drilling to deeper and more prolific oil-producing zones created new problems in design of pumping equipment. In many areas the necessity to produce higher capacities from greater depths showed the inadequacy of conventional pumps to transmit effectively the required horsepower from the surface to a point several thousand feet below ground where it was needed.

The introduction of a Reda bottom-hole pumping unit was an important development. The use of a submergible electric motor and a multistage centrifugal pump with one straight-line rotating part installed below the well fluid was revolutionary. The inherent characteristics of such a unit include the simplest form of electric motor, a highly efficient type of pump, plus the efficiency of transmitting electric power at moderate voltages for distances equal to the deepest oil well.

The inventor of Reda pumps, Mr. Armais Arutunoff, first conceived the idea of a submergible motor in Russia during the first World War. Experimentation was conducted in an attempt to develop an earth-burrowing machine which it was hoped would burrow from Russian trenches to German trenches. No satisfactory drilling bits were developed and the project was finally abandoned.

Many Russian mines had been flooded during the early stages of the war, and Mr. Arutunoff turned his attention toward the development of submergible mine dewatering pumps. These received wide application in mines and shallow oil and water wells.

The Communist revolution caused Mr. Arutunoff to leave Russia, and after spending a few years manufacturing the pumps in Germany, he decided to emigrate to the United States where political and economic conditions were most favorable for development of his pumping equipment.

Early experience in designing, building, testing, installing, and operating Reda pumps uncovered many difficulties that might not be apparent when first considering the problem. The present Reda unit is primarily a high-capacity pump in the oil industry and is installed in wells of varying depths to produce volumes as great as 15,000 barrels of fluid per day. Common well casing inside diameters of approximately five, six, or eight inches control Reda pump or motor diameters. To build a conventional motor and pump capable 10, 20, or 100 hydraul horsepower would involve r serious problems, but to c the same jobs with a diamet limitation of 6 inches, f example, requires somethi which is out of the ordinary.

To accomplish this, Reda uses a 2-pole 3-phase 60-cyc 3,600-rpm induction-type motor. Since the diamet must be small, greater horsepower is obtained by increasi the length of the motor. Field windings in all sizes a continuous throughout the length of the stator, but roto are made in short sections which are keyed to the sha with bearings between each rotor section to guide t shaft and help maintain perfect centering in the fiel Because alignment and straightness in the complete u is important, there is, of course, a limit to length. T longest motor made in a $5^7/_{16}$-inch outside diameter, or 500 Series, is rated at 135 horsepower and has a length 28 feet. Other motor sizes are made in the 500 Series f installation in 7-inch-outside-diameter well casing and a 450 Series for use in wells equipped with $5^1/_2$-inch casir A 738 Series motor is built in sizes up to 240 horsepow for $8^5/_8$-inch-outside-diameter casing. Comparable pun sizes are built in 400, 450, 500, 650, and other series f different casing diameters.

Reda motor voltages vary from 110 to 1,650, dependi on size, setting depth, and the available surface elect power which is transmitted to the motor through an and waterproof cable built according to Reda patents a specifications. Synthetic rubber insulation is protect from mechanical injury by an armor of interlocking st tape, and the cable is supported by clamping to the tubi at intervals from pump head to surface. Winding schem wire sizes, power factors, and efficiencies compare w conventional motors, but the technique of building t motor is one of the most unique features of the unit.

A Reda motor assembly is started with a section seamless steel tubing. Slotted steel and brass laminati are slipped over a long mandrel and pressed into the ho ing. The laminations are released in the housing a contained by snap rings after a load of approximately tons has been applied by a hydraulic press. This sta is then straightened to within 0.001 inch by peeni throughout its length.

With the 18 lamination slots in alignment through the length of the stator, mica and glass-insulated pa tubes are inserted and pulled into each slot preparatory winding. Bundles of steel rods are placed in each sl

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Full text of a conference paper presented at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950.

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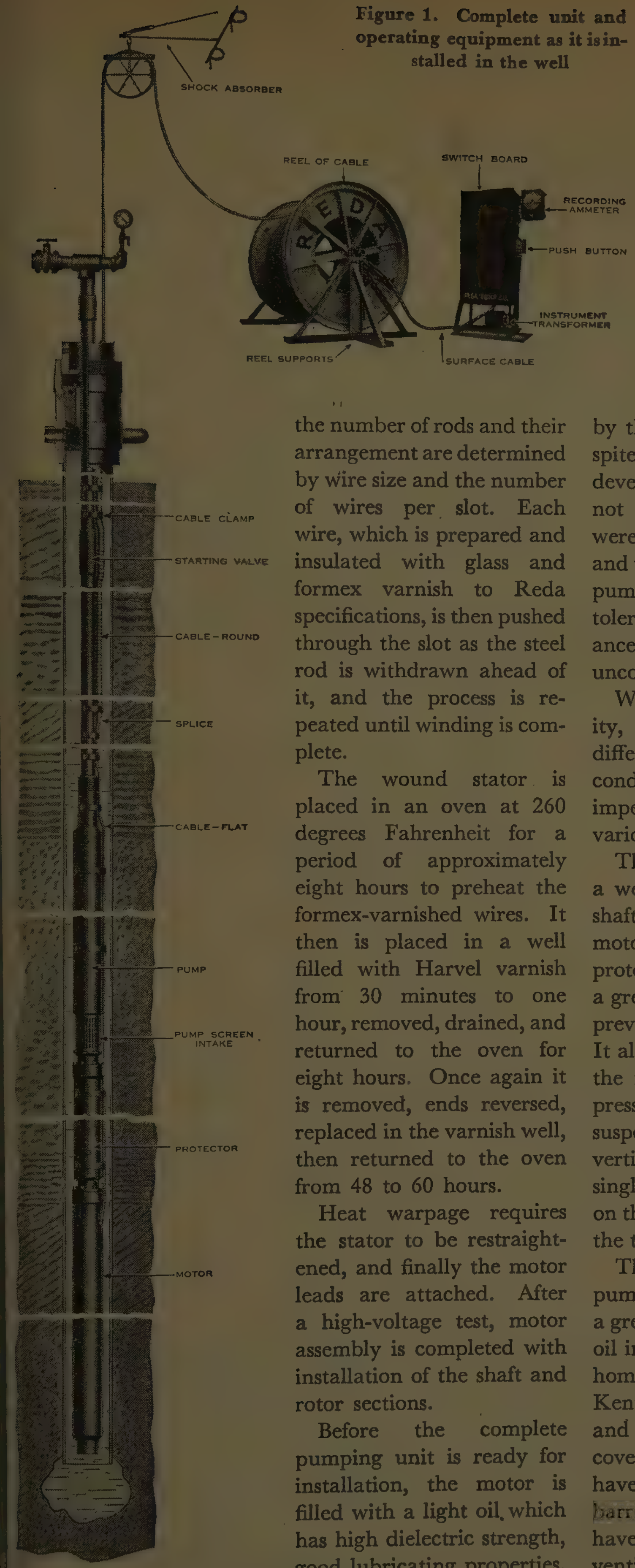

Figure 1. Complete unit and operating equipment as it is installed in the well

the number of rods and their arrangement are determined by wire size and the number of wires per slot. Each wire, which is prepared and insulated with glass and formex varnish to Reda specifications, is then pushed through the slot as the steel rod is withdrawn ahead of it, and the process is repeated until winding is complete.

The wound stator is placed in an oven at 260 degrees Fahrenheit for a period of approximately eight hours to preheat the formex-varnished wires. It then is placed in a well filled with Harvel varnish from 30 minutes to one hour, removed, drained, and returned to the oven for eight hours. Once again it is removed, ends reversed, replaced in the varnish well, then returned to the oven from 48 to 60 hours.

Heat warpage requires the stator to be restraightened, and finally the motor leads are attached. After a high-voltage test, motor assembly is completed with installation of the shaft and rotor sections.

Before the complete pumping unit is ready for installation, the motor is filled with a light oil, which has high dielectric strength, good lubricating properties, nd serves as an aid in cooling. Because of its submergence h relatively cool well fluid which passes between the well casing and motor housing, a Reda motor normally has high overload capacity. Some operators run motors continuously at overloads of 50 per cent or more with no ill effects.

A Reda submergible motor that is small physically, with good electrical and mechanical characteristics, is only a part of the unique features included in the complete unit. The same well casing diameters that limit motor dimensions restrict pump diameters even more because of the additional space that must be provided for passage of an electric cable by the pump to the top of the motor. In spite of this, the multistage centrifugal pump develops large volumes as well as high heads not believed possible before Reda pumps were introduced. To utilize fully the space and to obtain the highest possible efficiencies pump and motor design requires that close tolerances are held in all dimensions. Tolerances of 0.0005 inch or 0.001 inch are not uncommon for many pump and motor parts.

Widely varying conditions of lift, capacity, and casing sizes call for a number of different pump impeller types to fit these conditions. At present, approximately 25 impeller designs are commonly used for various applications.

The complete pumping unit as installed in a well (Figure 1) consists of a pump, the shaft of which is directly connected to the motor through a protector section. The protector contains a spring-backed piston, a grease chamber, and an oil chamber, and prevents well fluid from entering the motor. It also serves to equalize the pressure inside the motor with the external submergence pressure. The assembled unit (Figure 2) suspended on regular oil well tubing in its vertical operating position is essentially a single rotating shaft with the motor rotors on the lower end and the pump impellers on the top end.

The greatest oil field application for Reda pumps has been in water drive areas where a great fluid volume must be lifted to obtain oil in paying quantities. In fields in Oklahoma, Kansas, Texas, Illinois, Wyoming, Kentucky, Louisiana, Montana, Arkansas, and elsewhere, due to increased ultimate recoveries at high producing rates, operators have recovered millions of barrels of oil that could not have been produced with conventional pumping equipment.

A typical example of these results may be seen in the history of a well in Marion County, Kansas, which had

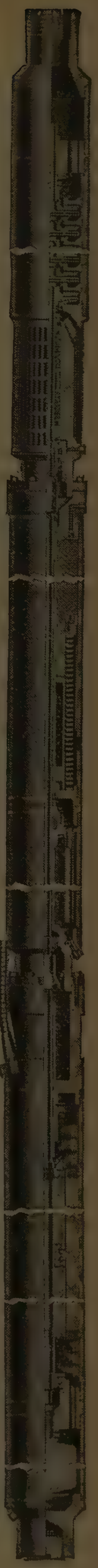

Figure 2. Quarter section of the pumping unit

been abandoned after 20 years of beam operation. Production with a high-capacity Reda unit installed in 1937 was 56 barrels of oil and approximately 6,700 barrels of water per day. This well is still equipped with a Reda and its present production, after 13 years, is 45 barrels of oil with 6,700 barrels of water per day. Since being abandoned after beam operation, the well has produced over 185,000 barrels of oil and over 23,000,000 barrels of salt water.

The economic and mechanical advantages of a submergible electric pump have been responsible for a widespread use of Reda pumps by chemical concerns. Wyandotte, Dow, Solvay, and many other companies using rock salt or natural brine as a basic raw material now are lifting brine to the surface with Reda units. The effects of severe corrosion in this application, as in many oil wells, showed the necessity of building pumps with corrosion-resistant materials. Standard pump construction of bronze impellers, cast iron diffusers, and steel shafting is altered wherever necessary to bronze impellers, Ni-Resist diffusers, and a *K*-Monel shaft. These materials have been highly successful, even in cases of extreme corrosion, and in many instances the pumps have operated continuously from 300 to 700 days or longer before replacements were necessary.

In the comparatively recent field of water flooding as a secondary recovery measure, Reda submergibles are used for installation in supply wells to produce large water volumes for injection into the oil producing zones. The automatic control features available with the Reda electric unit are proving valuable in this application.

Another recent submergible pump application extends into the water service industry in supplying fresh water for farms or suburban homes. Although the normal water we installation of this type does not require large pump capac ties or lifts comparable to oil wells, it has been found tha many such wells are equipped with casing as small as fou inches. To fulfill this need, $3^{3}/_{4}$-inch-outside-diameter uni in sizes of 4/10, 5/8, and $1^{1}/_{4}$ horsepower are being built t operate on 110- or 220-volt single-phase power. A com plete line of water-well pumps is being manufactured i sizes from 4/10 to $22^{1}/_{2}$ horsepower which are similar i design and operate on the same principle that has bee developed and improved over the past 25 years.

With the present drilling of deeper oil wells, new pumpin problems arise in the form of higher bottom hole temperatures, greater horsepower requirements, and much greate submergence pressures.

For example, the cable now used to transmit power fro the surface to the motor is built with insulation that highly impervious to oil and water at normal well temperatures and pressures, but to withstand effectively temperatures of 250 or 300 degrees Fahrenheit, or higher, and a pressures up to 4,000, 5,000, and 6,000 pounds per squar inch, or even greater, new insulating materials are bein developed and tested. Steadily improving materials suc as silicone, nylon, orlon, or other new plastics offer promis of suitable insulation qualities and all new developments ar given careful consideration and thorough tests to determin their value.

Preliminary Reda tests with frequencies from 60 to 18 cycles indicate the possibility of using high-frequency motor to pump extremely deep oil wells successfully. Furthe tests with higher speeds will undoubtedly reveal ne problems in design and material requirements.

Deterioration of Transformer Oil and Paper Insulation Caused by Temperature Changes

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SEVERAL YEARS ago, the question of overloading transformers for short times arose. This in turn brought up the question of insulation deterioration with both temperature and time.

It is a subject which is as old as the electrical industry, but nevertheless one which has no end. Because it fringes on the edge of chemistry and other subjects not at the finger tips of the electrical engineer, it is not understood as well a it should be. During the war, materials not oilproo which caused accelerated deterioration, often were use showing that designing engineers for some manufacture were not aware of the problem. In earlier days this wa common throughout the industry, as a number of material impregnants, and varnishes were used which accelerate deterioration.

The effect of different materials also is affected by the u of inert gas over the oil. Since most transformers now a either sealed or protected from oxygen, this is the mo important condition. The use of this protection raise

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Full text of paper 51-4, "Deterioration of Transformer Oil and Paper Insulation by Temperatures," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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again the question of the rate of insulation deterioration with short time overloads.

There have been a number of papers on the subject recently. One of these papers reported a joint investigation[1] which was made because of some difference in opinion based on the results of different observers. The results of the joint investigation could lead to conclusions at variance with some previously obtained data.[2,3] In this case, curiosity as to the cause naturally was aroused, and to satisfy this, the work reported in this article was done. At the same time, some other questions arose, and these were investigated.

These questions were as follows: If air or oxygen is not present, does oil itself deteriorate due to temperature and time? The belief has been expressed that changes would be small. Also, the catalytic nature of copper is known, so tests with both tough-pitch and oxygen-free copper were made in combination with oil sealed from oxygen or air. The effect on the oil of silicon steel, with both a common-core plate enamel and a so-called 'glass' coating, was tested also. Since the reason for the reported differences stated previously was perhaps in the papers tested, tests were made with manila paper, kraft paper, and rag paper under oil. Also, varnish-treated samples and other combinations were ested.

If air or oxygen is not present, does transformer oil deteriorate due to temperature and time? A detailed study of this question was made recently, and the results are presented here.

The results of the tests indicated that some changes took place even in the oil alone, but that in some cases it was accelerated by the presence of other materials. Also, there were distinct differences due to the materials, as the oxygen-ree copper, 'glass'-covered iron, and kraft or rag papers led o the least deterioration. It was further noted that the atter papers tended to absorb the high-power-factor materials resulting from the oil deterioration. This reduced the power factor of the oil and increased the power actor of the paper. However, the results do not indicate ny changes in the present recommendations for loading ransformers, but do throw some light on the changes which ake place.

PREPARATION OF SAMPLES

SIX OF EACH TYPE sample were prepared, three to be aged at 105 degrees centigrade, and three to be aged t 120 degrees centigrade. Each sample comprised a 1-ch by 8-inch Pyrex test tube into which were placed varius transformer materials, covered with a standard type of ansformer oil, and sealed after suitable treatment.

The types of samples follow:

1. (a) Untreated kraft paper, 12 strips.
   (b) Untreated manila rope paper, 12 strips.
   (c) Untreated rag stock paper, 12 strips.
2. (a) Tough-pitch copper.
   (b) Oxygen-free copper.
3. Control sample—oil alone.
4. Kraft paper wrapped around oxygen-free copper, ed, dipped in phenol-alkyd varnish, and baked in accordance with instructions of one of the large electrical manufacturers.
5. (a) Hot-rolled silicon steel, coated with a standard core plate enamel; four strips.
   (b) Cold-rolled silicon steel, coated with glass; four strips.
6. (a) Untreated manila paper and four strips hot-rolled silicon steel, coated with a standard core plate enamel.
   (b) Untreated manila paper and four strips cold-rolled silicon steel, coated with glass.

The dimensions of the materials in inches were:

Kraft and manila papers: 1/2 by 10 by 0.003
Rag stock paper: 1/2 by 10 by 0.004
Tough-pitch copper: 1/4 by 1/4 by $3^1/_8$
Oxygen-free copper: 3/8 by 1/8 by 3
Silicon steel: 1/2 by 3 by 0.014

In preparing the sealed samples, the dry material was placed in the open test tube, the tube was sealed to an exhaust manifold, and a vacuum of 1/4 inch of mercury was applied for four hours. Transformer oil, at room temperature, was allowed to run slowly into the evacuated tube. The oil adhering to the neck of the tube was volatilized, while still under vacuum, by application of heat. Dry nitrogen was introduced into the tube, and the tube was sealed without heating the oil.

TEST METHOD

AFTER AN aging period of one year, the samples were permitted to cool to room temperature. Power-factor measurements at 60 cycles were made on the oil of each type sample, using a gradient of 27 volts per mil. Measurements were made at room temperature and at 100 degrees centigrade.

Tensile strength tests were made on the paper strips using a 3/8-inch throat 1 inch long cut in each paper strip. In most cases seven measurements were averaged to determine the strength of a particular sample. For comparative purposes, tensile strength was measured on oil-soaked paper strips which were not aged.

Some samples were tested for acidity in accordance with American Standards for Testing Materials.[4]

RESULTS OF TESTS

THE RESULTS of the tests on the oil alone are given in Table I.

Table I. Oil Only

Test	Original	Sample Aged at 105°C
Acidity	0.035	0.04
Power factor—Room temperature	0.0007	0.0032
Power factor—100°C	0.00125	0.0066
Power factor—Room temperature after cooling		0.0027
Color		No change

The results of the tests indicate a definite change in the molecular structure of the oil, due to the change in power factor. It is to be noted that there was little change in acidity. There was little change in oil color.

The test results on oil with tough-pitch copper and oxygen-free copper are shown in Tables II and III.

Table II. Oil With Tough-Pitch Copper

Test	Sample Aged at 105°C	Sample Aged at 120°C
Acidity	Less than 0.03	Less than 0.03
Power factor—Room temperature	0.0123	0.068
Power factor—100°C	0.153–0.195	0.245
Color oil	Little change	Yellowed slightly

Table III. Oil With Oxygen-Free Copper

Test	Sample Aged at 105°C	Sample Aged at 120°C
Acidity	0.03	0.03
Power factor—Room temperature	0.0076	0.044
Power factor—100°C	0.134–0.154	0.144
Color oil	Little change	Little change

The presence of the copper, even when oxygen-free, resulted in a considerable increase in power factor. The acidity, in both cases, was little changed.

The test results with the untreated papers are given in Tables IV, V, and VI.

Table IV. Oil and Untreated Kraft Paper

Test	Original	Sample Aged at 105°C	Sample Aged at 120°C
Oil power factor—Room temperature		0.0001	0.0085–0.0019
Oil power factor—100°C		0.0019	0.0016
Tensile strength of paper, pounds	16	12	2
Oil color		Little change	Yellow
Paper color—Room temperature	Tan	Tan	Nearly black
Paper power factor	0.005 approximately	0.024	0.573

It should be noted that the power factor of the oil after the test changed with exposure to air, the higher values given being values obtained soon after opening the samples, and the latter after approximately 16 hours' exposure. Evidently some of the deterioration products were highly volatile, and the paper absorbed the high-power-factor materials.

Table V. Oil and Untreated Manila Paper

Test	Original	Sample Aged at 105°C	Sample Aged at 120°C
Oil acidity		0.25	0.59
Oil power factor—Room temperature		0.0002	0.025–0.0123*
Oil power factor—100°C		0.0017	0.0032
Tensile strength of paper, pounds	20	2.8	2.3
Color oil		Little change	Discolored and cloudy
Color paper	Yellow	Nearly black	Black
Paper power factor		0.417	0.542

* When the sample was opened, the oil bubbled and emitted an odor of charred paper. The power factor of the oil changed, and even decreased with heating to 100 degrees centigrade. The power factor of the same sample, after cooling, decreased ultimately to 0.01 per cent.

It is of interest that the kraft and rag papers seemed much more stable than the manila paper. The presence of any paper seemed to reduce the power factor of the oil, but increased acidity, as indicated by Table I. It is very apparent that the tests made using manila paper showe markedly increased acidity and power factor over thos using the rag paper.

Table VI. Oil and Rag Paper

Test	Original	Sample Aged at 105°C	Sample Age at 120°C
Oil acidity		0.06	0.36
Oil power factor—Room temperature		0.0001	0.0001*
Oil power factor—100°C		0.0011	0.0014
Tensile strength of paper, pounds	22	8.3	5.7
Color oil		Little change	Little chang fairly clea
Color paper	Blue	Tan	Nearly black
Paper power factor	0.005 approximately	0.0125	

* The sample aged at 120 degrees centigrade had an odor of charred paper whe opened.

Since the co-operative tests, previously referred to, use manila paper only, it is seen that they are not representative of what might happen with transformers using some ra and kraft materials. It is believed also that it would b advantageous to remove the volatile deterioration products particularly those produced by the manila paper, durin operation.

The series of tests made with steel and with steel an manila paper are given in Tables VII, VIII, IX, and X.

Table VII. Oil and Silicon Steel and Core Plate Enamel

Test	Sample Aged at 105°C	Sample Aged at 120°C
Oil power factor—Room temperature	0.00082	0.0023
Oil power factor—100°C	0.0153	0.037 to 0.001 after 16 hou
Color oil	Little change	Little chang sour smell

Table VIII. Oil and Glass-Coated Silicon Steel

Test	Sample Aged at 105°C		Sample Aged at 120°C	
	A*	B*	A*	B*
Oil power factor—Room temperature	0.0066	0.0041–0.0011	0.0005	0.046
Oil power factor—100°C	0.129	0.0300	0.0117	0.004
Oil cooled to room temperature after 78 hours				0.000
Color oil	No change		No change	

* A and B refer to two separate samples.

In these tests, it still appears that the effect of the ste and coatings is to create a volatile material resulting in th high values of power factor which decrease markedly o exposure to air.

Table IX. Oil, Silicon Steel and Core Plate Enamel, and Untreate Manila Paper

Test	Sample Aged at 105°C	Sample Aged at 120°
Oil acidity	0.28	0.28
Oil power factor—Room temperature	0.0003	0.0603
Oil power factor—100°C	0.0227	0.0028
Oil power factor—Cooled to room temperature		0.0004 after 16 hours
Tensile strength of paper, pounds	4.1	2.2
Color oil	Badly yellowed	Yellow and much sed ment
Color paper and steel	Both darkened	Both black; oil froth when opened; charr odor

Table X. Oil, Silicon Steel With Glass Coating, and Untreated Manila Paper

Test	Sample Aged at 105°C	Sample Aged at 120°C.
Oil acidity	0.06	0.45
Oil power factor—Room temperature	0.0003	0.0016–0.0009 after 1 hour
Oil power factor—100°C	0.0010	0.0024
Tensile strength of paper, pounds	2.3	1.9
Color oil	Slightly yellow	Yellow
Color paper and steel	Paper darkened, steel black	Black, oil frothed when opened

The preceding tests showed that the deterioration was affected greatest by the core plate enamel, and the products causing the high power factor were eliminated by heating or exposure to the atmosphere.

The results of the tests using impregnating materials are shown in Tables XI and XII.

Table XI. Oil, Oxygen-Free Copper, Synthetic Varnish on Kraft Paper

Test	Sample Aged at 105°C	Sample Aged at 120°C
Acidity	0.85	1.06
Power factor—Room temperature	0.0211	0.0167
Power factor—100°C	0.0364	0.0302
Oil condition	Yellow and sediment	Yellow, much sediment; charred paper odor

The treated paper was extremely brittle, showing very little strength.

Table XII. Oil and Black Treated Tape

Test	Sample Aged at 105°C	Sample Aged at 120°C
Acidity	0.78	1.15
Power factor—Room temperature	0.52	Practically unity
Oil color	Black	Black

DISCUSSION AND CONCLUSIONS

EVEN WITHOUT the presence of oxygen, some change in the oil was indicated by the change in power factor of the oil. This occurred also in the presence of copper as well as in the presence of iron and the glass coating.

The papers seemed to absorb some of this high-power-factor material from the oil. The oil then remained with a low power factor and the power factor of the paper increased tremendously. It was noted that deterioration products causing the high power factors seemed to be volatile, as the power factors of the oil decreased with exposure to air.

As in the previous tests, the paper was found to be very brittle. Higher strength values after test than given here were reported before,[1] but the length of samples were shorter in these tests and it was more difficult to avoid clamping difficulties in the tensile strength tests.

It is to be noted that both the kraft and rag papers resist heating much better than manila paper. It is believed that new manila paper has a little stretch, and this enables it to be taped on rectangular conductors faster and with less breakage. However, transformers use the kraft and rag materials where the heating is less, and the manila directly against the hot copper.

It seems that the presence of the varnishes or enamels affect the oil adversely. In the case of the steel core plate enamel, sediment, gas, and discoloration were produced. This also occurred with the phenol-alkyd varnish, which was represented as being an oilproof and satisfactory varnish for transformer impregnation. The test on the black treated tape was included because even though it is not usually claimed to be oilproof, it sometimes is used even today.

It is interesting that there are two other papers reporting tests on transformer assemblies.[5,6] In the case of one of these,[5] it is believed that these tests form a rough explanation of why some of the results took place. In the case of the other paper,[6] the statement that the condition of the oil is affected by the materials used and that in turn the materials are affected by the oil could be inferred, and is confirmed by the results of these tests. Since the oil deterioration or change may not be wholly one of oxidation, one might be led to question the effect of inhibitors, as raised in the latter paper.[6] The best idea might be to prevent oxidation and remove the deterioration products evidently produced by the oil and paper.

When this work was started, it was thought that it might have some application to the previous work on transformer insulation life. As a result of it, the authors believe the mathematical and experimental foundations are not too well founded, but that the recommendations as made and used are satisfactory in giving usable results. More care in the selection of materials and in the removal of deterioration products will lead to longer transformer life.

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Improvements Made in French TV

Tele-Paris, television station of the French capital, will offer early this year about 25 hours of telecasts weekly at the high definition of 819 lines. The announcement was made by Albert Gazier, Minister of Information, in a recent report to the Press Committee of the French National Assembly. Simultaneously with these new telecasts, 25 hours of telecasts on 441 lines will continue in the Paris region until at least 1958. The standard line definition in the United States is 525. The recently installed television transmitter at Lille, France, telecasts 15 hours per week on the 819-line definition. French television has made successful experiments with color television. In 1951, France will spend 115 million francs (approximately $330,000) to finance its television programs.

A Submarine Telephone Cable With Submerged Repeaters

J. J. GILBERT
MEMBER AIEE

Repeaters designed for long life are incorporated in the cable structure and are laid as part of the cable of the recently installed Key West—Havana submarine telephone cable system. To eliminate the need for servicing the repeaters, the components were designed so that parts would not have to be replaced for 20 years or more.

IN APRIL 1950 there was installed between Key West, Fla., and Havana, Cuba, a submarine telephone cable system involving a radical departure from the conventional art of long-distance submarine telephony. This departure consisted of the inclusion within the armor of the submarine cable of electron-tube repeaters which are designed to pass through the cable-laying machinery and sink to the ocean bottom like a length of cable, and which, over an extended period of perhaps 20 years, should not require servicing for the purpose of changing electron tubes or defective circuit elements. The repeater has the appearance of a bulge in the cable about three inches in diameter and tapering off in both directions to the cable diameter of a little over an inch. Total length of the bulge, including the taper at each end, is about 35 feet. The bulge is flexible enough so that it can conform to the curvature of the brake drum and the various sheaves in the laying gear on the cable ship. A repeater, with stub cables, is shown in Figure 1.

The new cable system, comprising cables Numbers 5 and 6 of the Cuban-American Telephone and Telegraph Company, represents another step in the development of telephonic communication between the United States and Cuba, which has presented many interesting problems. Natural conditions make it difficult, if not impossible, to employ some of the usual methods of communication. One such condition is the absence of high ground in Florida that would permit the use of economic radio systems. Another is the stretch of water between Florida and Cuba, which, in places, is as much as 6,000 feet in depth and which restricts the type of cable that can be used. The practical solution has been to go from the point of contact with the Bell Telephone system toll lines at Miami, over the Keys to Key West by land line (with some water crossings), thence to Havana, an air line distance of about 100 nautical miles, by submarine cable of the deep-sea type of construction, having a single coaxial circuit, insulated with water-resistant material.

SUBMERGED REPEATERS

THE DEMAND for circuits to Havana has continued to grow, and, after the close of World War II, the time appeared ripe for making use of a new development which had just come to a head in the Bell Telephone Laboratories after a period of experimentation. This development was the submerged repeater. The need for periodic strengthening of signals transmitted over considerable distances is about the same in submarine cables as it is in land lines and, as in land lines, the permissible spacing between repeaters usually diminishes as the desired frequency increases. The great difficulty in the case of submarine cable routes is that there are usually no land sites on which repeaters can be located. Artificial islands consisting of floating platforms or buoys have been proposed as a solution but ocean currents and storms have disastrous effects on such structures. Interruptions due to such causes would make it difficult to meet the requirement on continuity of service which is necessary in the case of important telephone circuits. Therefore, it appeared that the safest place for a submarine cable repeater is on the ocean bottom.

REQUIREMENTS ON REPEATER

THE DECISION to place the repeater on the ocean bottom resulted in special requirements on the structure, the first of which is that it be capable of resisting the considerable hydrostatic pressure that is encountered in deep water. It also seemed desirable that the operation of getting the repeater overboard from the cable ship should not impede the smooth functioning of the laying process. The best way of meeting this requirement appeared to be to make the repeater structure flexible, within practicable limits, and as small as possible in diameter so that it could pass around the drum and sheaves of the laying gear like any length of cable.

In order to make such a repeater attractive from operating and commercial points of view another requirement was necessary, namely, that the electric circuit elements of the repeater, including electron tubes, resistances, capacitors, and coils be designed for long life under operating conditions, so that there would be assurance of freedom of trouble or need of replacement of parts over a long period, perhaps 20 years or more.

There was still another requirement on circuit elements that of ruggedness. The stresses involved in laying cable in deep waters are quite considerable. The cable is under a tension of several thousand pounds and incident might occur which would have no effect on an ordinary

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Essential text of paper **51-94**, "A Submarine Telephone Cable with Submerged Repeaters," recommended by the AIEE Committee on Wire Communication Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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cable but which might result in dangerous shocks to the delicate elements of the repeater.

THE REPEATER HOUSING

THE REQUIREMENTS on flexibility and watertightness under ocean-bottom pressures were the factors of outstanding influence in the design of the repeater housing and of the end seals by means of which the cable enters and leaves the housing. In the present form the housing consists of a long tube of soft copper $1^3/_4$ inches in diameter and 0.03 inch thick, supported internally against collapse under sea-bottom pressure by an assemblage of abutting steel rings, each 3/4 inch wide, and given a degree of rigidity by means of thinner steel rings of the same width overlaying and staggered relative to the thicker rings. When this structure is sealed at the ends it is capable of withstanding pressures as high as 10,000 pounds per square inch, and it can be bent to a radius as small as three feet without undue distortion of the copper envelope.

Into each end of the housing is led the insulated conductor of the cable by means of a series of seals. The inner or vapor seal is of the glass-metal type especially developed for this particular purpose and capable of withstanding considerable hydrostatic pressures. Next in line there is a seal comprising a central brass tube and an external brass member, both vulcanized to rubber, which is joined to the insulating material of the cable. These seals are coaxial in form, the outer member in each case being brazed to the copper tube of the housing or an extension thereof. Finally a closely fitting "core tube" of copper, extending over the cable insulation for a distance of about seven feet, is brazed to an extension of the copper envelope of the housing, filled with Vistac, and sealed at the distant end by means of a Neoprene sleeve joined firmly to the core tube and to the cable insulation.

The repeater housing and core tube are provided with corrosion protection layers and a bedding for the armor wires, the bedding over the core tube being built up in the form of a taper. The armor is a continuation of the cable armor wires with additional wires interspersed to allow for the larger diameter of the repeater. To prevent twisting of the container due to the unlaying of the armor wires under tension, a second layer of wires with a direction of lay opposite to that of the main armor is employed. The repeater may be armored as part of the cable or it may be armored separately, with a stub on each end, and spliced into the cable.

THE REPEATER CIRCUIT

THE DIAMETER of the housing had been chosen originally on the assumption that the bulge caused by the repeater should not be more than two or three times the diameter of the cable proper in order to reduce the possibility of overriding turns on the brake drum during laying. Mechanical tests indicated that this diameter was also safe from the standpoint of deformation of the copper envelope during bending. Accordingly, it was required that the repeater structure should be restricted in cross section so it would fit inside this tube, with as much length as needed.

The problem then became one of packaging the elements involved in a high-gain electron-tube amplifier in the restricted space available. The completed amplifier consists of an articulated assemblage of composite Lucite cylinders, each about five inches long, successive units being held together by a spring assembly. Each Lucite cylinder contains the related electrical elements of a particular part of the repeater circuit. The groups of smaller elements are mounted rigidly in a Lucite form which slides into an insulating envelope consisting of two close-fitting Lucite shells and is held in place by end pieces of Lucite. Eight copper tapes laid in axial slots between the shells and extending over several sections, where necessary, permit electrical interconnection of the various parts. A representative assemblage is shown in Figure 2. In the case of the Key West–Havana repeater the complete assemblage is 84 inches long and comprises 15 sections.

Figure 1. Submarine cable repeater

CIRCUIT ELEMENTS

EARLY in the development general principles were developed regarding the type of circuit best suited for underwater repeaters, and on this basis requirements were established on the characteristics necessary for the circuit elements, including electron tubes, and on their arrangement in the repeater. Decisions in such matters could not be arbitrary but had to be worked out in order to freeze designs as early as possible to facilitate the start of life tests.

The electron tube is the most important of the elements. Work had been begun on a tube suitable for this use as far back as 1933. Thus when a decision was made to lay the

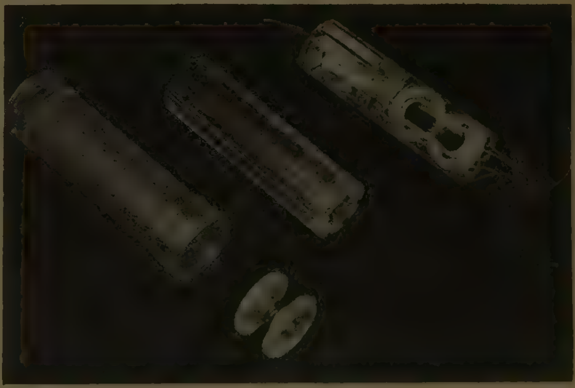


Figure 2. Typical section of repeater

new cables, a long background of experience was drawn on in the manufacture of the tubes. Early models of the type had been operated on continuous life test for as much as ten years. Designed primarily for long life, the tube is a suppressor-grid pentode with an indirectly heated cathode. Of rugged design to withstand the shocks of cable laying, the spacings between electrodes are relatively large. Unusual care was taken in manufacture to insure solid welds and to avoid the presence of loose particles. During various stages of assembly, rigorous inspections were made on all tubes by engineering personnel. Selection of tubes for use in the cable was based on a thorough examination of all details in the history of each tube, as well as the history of the group in which it was manufactured. All tubes which were candidates for the cable were aged several thousand hours before preliminary selection was made. In addition, other tubes from the same production group were further life-tested several more thousand hours to establish the quality of the group. One early decision was to power repeaters by direct current fed from land over the cable conductor. The tube heaters connected in series would furnish plate and grid potentials. This was an important factor in setting the nominal requirements for the tube, which are about 1/4 ampere at 20 volts for heater supply and plate potentials of 40 to 60 volts.

While the electron tube is usually the most vulnerable element in electric circuits from the standpoint of life, attention must be given to other elements—capacitors, resistances, and coils—especially where they are subject to long continued application of electric potentials as in the case of power separation filters. The factors that determine the life and performance of these elements are not completely under control. It was felt, however, that the best assurance on dependability could be obtained by careful, conservative design and by manufacturing and assembling the elements into repeaters under the best possible conditions of cleanliness. An air-conditioned space was provided for this purpose at the Murray Hill Laboratory. In addition to cleaning the air in this space, precautions were taken against the entrance of dirt by other means, for example, on the clothing or persons of operators. The humidity of the air was carefully controlled to preven contamination from perspiration during handling.

FIELD TRIALS

SIMULATED laying tests in the laboratory covered a perio of several years. Special pains had been taken t include as far as possible all aspects of the laying operation, even those which were judged to be free of hazard to the repeater. Tests also were made to determine the effect, if any, of the laying operation upon the electric transmission characteristics of the cable. Likewise, comprehensive electrical tests had been made to insure that n unexpected effects would be encountered due to the immersion of the repeater in water.

A large-scale test was needed, however, to establish the practicability of the repeatered cable. This is because during the laying operation the suspended length of cable trailing the ship may be as great as ten nautical miles o more, and in this length there occur complex mechanical phenomena which cannot be simulated in the laboratory with a great degree of assurance. After preliminary trials from a barge in Long Island Sound, a deep water test o the repeatered cable was made in 1948 in the Bahamas. The cable ship, *Lord Kelvin*, of the Western Union Telegraph Company was chartered for the purpose. Lengths of cable up to 15 nautical miles were payed out along with repeaters in depths of water up to 2 nautical miles. Several repeaters were laid, measured while on the ocean bottom, and then hauled back to the ship, a procedure that involves much more severe treatment than a mere laying operation. The repeater shown in Figure 1 experienced this treatment. Tests also were made with repeater housings containing specially designed accelerometers to determine the shocks resulting from possible abuse during laying. The results indicated that the repeaters as well as the cable could take the punishment with a considerable margin of safety.

THE TRANSMISSION SYSTEM

DESIGNING the electric circuit of the repeater was largely a matter of getting the most out of the long-life electron tube in the way of stability of repeater gain and low modulation while obtaining as much gai as the system permits. For mos efficient use of tubes and to simplify structure, a unidirectional repeate design was decided upon.

The repeater employed in th Key West–Havana cables has thre stages with negative feedback, th circuit being as shown in Figure 3 The transmission band is from 1 kc to 120 kc. The insertion gai at 108 kc, the top frequency em ployed in traffic, is 65 decibel The repeater gain, which varie with frequency as shown in Figur 4, equalizes the loss of about 3 nautical miles of cable.

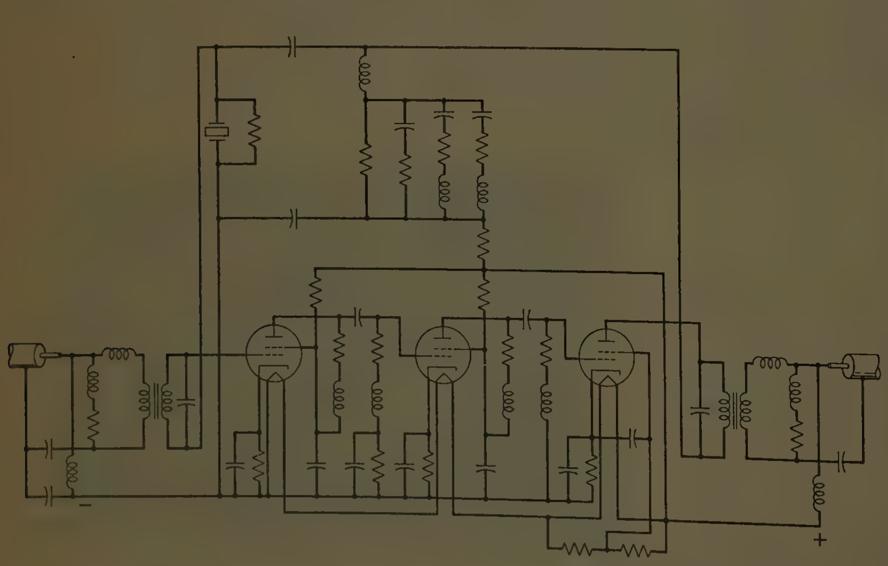


Figure 3. The repeater circuit has three stages with negative feedback

The layout of the new repeatered cable installation is shown in Figure 5. There are two cables, one for each direction of transmission. The East, or Number 5 cable, transmitting south, is 114.55 nautical miles in length. The West, or Number 6 cable, transmits north and is 124.97 nautical miles in length. Each cable has three repeaters spaced approximately 36 nautical miles apart. Two of the six repeaters are in a depth of 0.9 nautical mile and two in about 0.35 nautical mile. The last repeater in each cable is located as close as possible to deep water so as to strengthen the signal before it enters shallow water and land sections of cable where static noise and cross-talk might be picked up. In Havana the last repeater is located in a large vault on the beach. At Key West the last repeater is located close to Sand Key Light where the water begins to deepen.

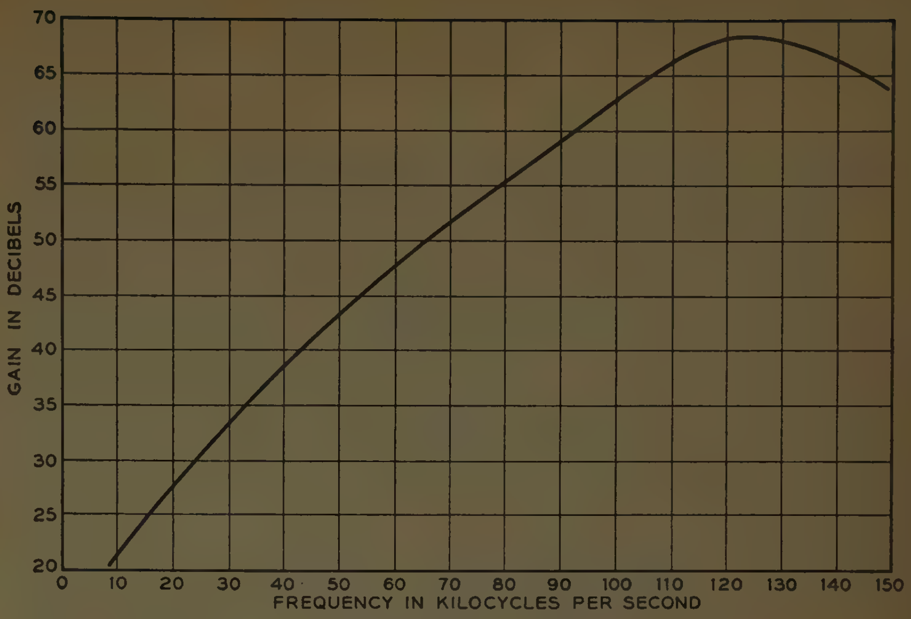


Figure 4. **Gain versus frequency characteristic of repeater**

At manholes near the shore at both ends the cables are spliced directly to underground cables running in ducts to the terminal equipment at the offices, a distance of three miles at Havana and one mile at Key West. The underground cables have the same coaxial circuit as the submarine cables, but in place of the mechanical protection of jute and armor they are provided with electrical protection of helical steel tapes, layers of paper, and over all a lead sheath.

The 12-kc to 108-kc passband yields 24 channels in each cable, each channel occupying a band of 4 kc. The signal-to-noise ratio for these channels is about the same as for the same length of high-grade carrier-frequency circuit on land.

THE CABLE

THE CABLE has a copper return, as in the case of the earlier installations, but differs from them in being insulated with polyethylene. It also involves some new principles of design that render the cable circuit less subject to change of electrical characteristics due to laying stresses. This is a matter of considerable importance in the case of a system with submerged repeaters, since after the cable has reached the bottom it is impossible to adjust the repeater to compensate for changes in cable attenuation during laying, a matter that in ordinary cables is taken care of by adjusting the equipment on shore.

In order to avoid undesirable irregularities in transmission characteristics, special precautions were taken during manufacture to obtain a higher than usual degree of uniformity of the cable impedance as seen by a repeater. Due to the wide transmission band, schemes heretofore employed for reducing the effect of the variation of impedance among the core lengths constituting the cable would have called for core lengths so short that they would seriously increase the number of joints. The irregularities were, therefore, minimized by careful control of conductor and insulation diameters and by continuously insulating lengths of the order of 12 nautical miles, cutting them only as was necessary for handling, and reassembling the shorter lengths as far as possible in insulating order to assure random addition of reflections due to impedance irregularities. The success of this technique is evidenced by the impedance deviation curves shown in Figure 6.

The central conductor of the cable consists of a solid wire 0.131 inch in diameter on which are laid three copper tape surrounds each 0.0145 inch thick and 0.148 inch wide, closely conforming to the solid wire. The interstices of the conductor are filled with polyethylene. The stranded conductor, 0.160 inch in diameter, is insulated with polyethylene to a diameter of 0.460 inch. Directly on the polyethylene insulation is laid the return conductor comprising six copper tapes, each approximately 0.016 inch thick by 0.241 inch wide, preshaped so that when in place they conform to the surface of the insulation. Both the return tapes and the tape surrounds of the central conductor have left-hand lay. Over the return conductor is wound a teredo tape approximately 0.003 inch thick with overlap. Over all is the cutched jute, the armor, and the outer jute serving to which are applied the usual cable compounds. Four types of armor are employed in the cable for use in various depths of water or for special use in shore conditions.

During the course of manufacture and in splicing on board ship, joints in the copper conductors were silver soldered. For joining the polyethylene insulation a special molding machine was designed and built by means of which polyethylene under high pressure and an elevated temperature was applied to the surfaces to be joined.

The cable was manufactured by the Simplex Wire and Cable Company of Cambridge, Mass., and incorporated the results of a co-operative development program conducted by that company and the Bell Telephone Laboratories. The excellent quality of the cable is a tribute to the manufacturer in this very difficult and exacting field.

TERMINAL EQUIPMENT

The transmission apparatus at Key West and Havana is mostly standard equipment employed in land-line carrier systems, and the operations involved in combining the 24 voice circuits into one band and separating them again are largely conventional. Special equalizers, power separation filters, and an auxiliary amplifier had to be designed, and the standard transmitting amplifier used in the *J* system was modified to accommodate the lower frequency band. A feature of particular interest is the equipment for testing the electrical condition of the repeaters from measurements at Key West. Each repeater contains a sharply tuned circuit by means of which the gain of the repeater is increased above normal at a distinctive frequency outside the transmission band of the repeater. With the aid of a loop circuit at Havana the gain with reduced feedback of the individual repeaters can be measured by scanning the test frequency region with an oscillator and detector at Key West. An indication of incipient decay of gain of any repeater is thus given.

The power for the repeaters is supplied over the cable conductor from Key West. A positive potential of about 250 volts is applied to one cable and −250 volts to the other, with a loop connection between the two cables at Havana to complete the d-c circuit. This neutral point also is connected to ground. The current in the cable conductors is at present maintained at 0.23 ampere. Precautions are taken against interruption of the power supply to the cable, and sensitive controls are provided to maintain the current constant in spite of earth currents and to guard against excessive currents or potentials in the cable system.

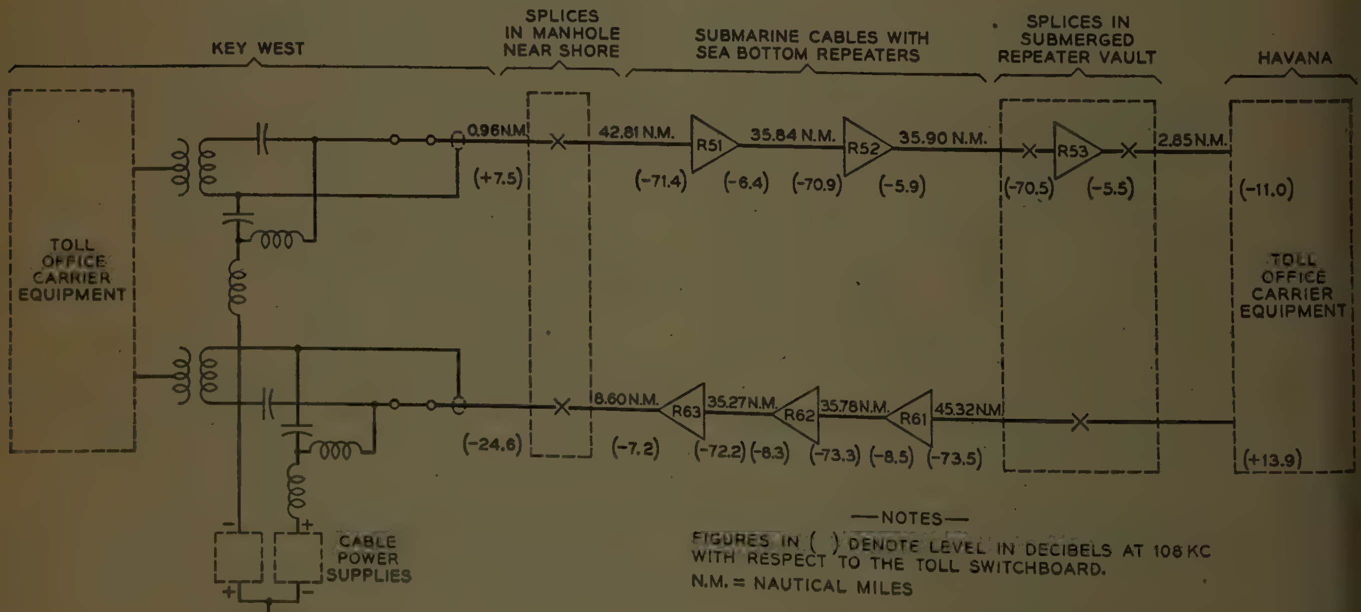
LAYING THE CABLES

The laying of the cables was completed without undue incident by the cable ship *Lord Kelvin.* The task was one of unusual difficulty since modifications had to be made in the cable-laying gear, some of them untried, and it was particularly desirable that the prescribed lengths and courses be realized.

Modifications were made in the cable-laying gear in order to obtain an additional margin of safety in laying repeaters. As was previously indicated, the repeater is capable of bending without harm on a diameter of approximately 72 inches, and the existing cable drum, approximately 68 inches in diameter, would have been adequate. It was felt desirable, however, to build the drum on the *Lord Kelvin* out to an 85-inch diameter to match the diameter of the bow sheaves. The dynamometer sheaves and the sheave leading the cable off from the brake drum presented more of a problem. The lead-off sheave was replaced by a ring sheave, 85 inches in diameter, supported on wheel bearings. The frame supporting these bearings was hinged at one end and the pressure on the other end of the frame, due to the tension of the cable passing over the sheave, offered a ready means for measuring this tension. For this purpose a resistance pressure cell was employed with a recorder, which not only gave a continuous record of tension but also relayed the signals to a vertical indicator on deck for the guidance of the brake operator, and to a smaller indicator on the bridge. It is felt that the arrangement has much to recommend it over the conventional dynamometer from the standpoints of sensitivity and quickness of response.

It was important to measure the transmission characteristics of the repeatered cable before, during, and after laying, and the special equipment needed for this purpose was more than could be contained in the electrician's room usually provided on cable ships. The jointers' storeroom was accordingly converted into an electrical laboratory.

The cable, loaded on board the *Lord Kelvin*, with the deep sea repeaters spliced in and stowed away in the tanks, arrived off Key West on April 21, 1950. Courses had been laid out for the two cables with the idea of keeping a



—NOTES—

FIGURES IN ( ) DENOTE LEVEL IN DECIBELS AT 108 KC WITH RESPECT TO THE TOLL SWITCHBOARD.

N.M. = NAUTICAL MILES

Figure 5. Layout of repeatered cables

5-mile separation between the two most of the way, and a 5-mile separation from the nearest of the cables that constitute the rather complicated network between Key West and Havana. It is hoped thereby to avoid having the new cables picked up by mistake when one of the other cables needs repair and to avoid confusing the two cables in case either one of them is in need of repairs.

The stretch of water between Key West and Sand Key Light, a distance of about eight nautical miles, is too shallow for the operation of a ship of the size of the *Lord Kelvin* so the sections of the two cables in this area had been laid from barges by the Long Lines Department of the American Telephone and Telegraph Company. At Havana a new landing place had been selected which was about three miles from the harbor.

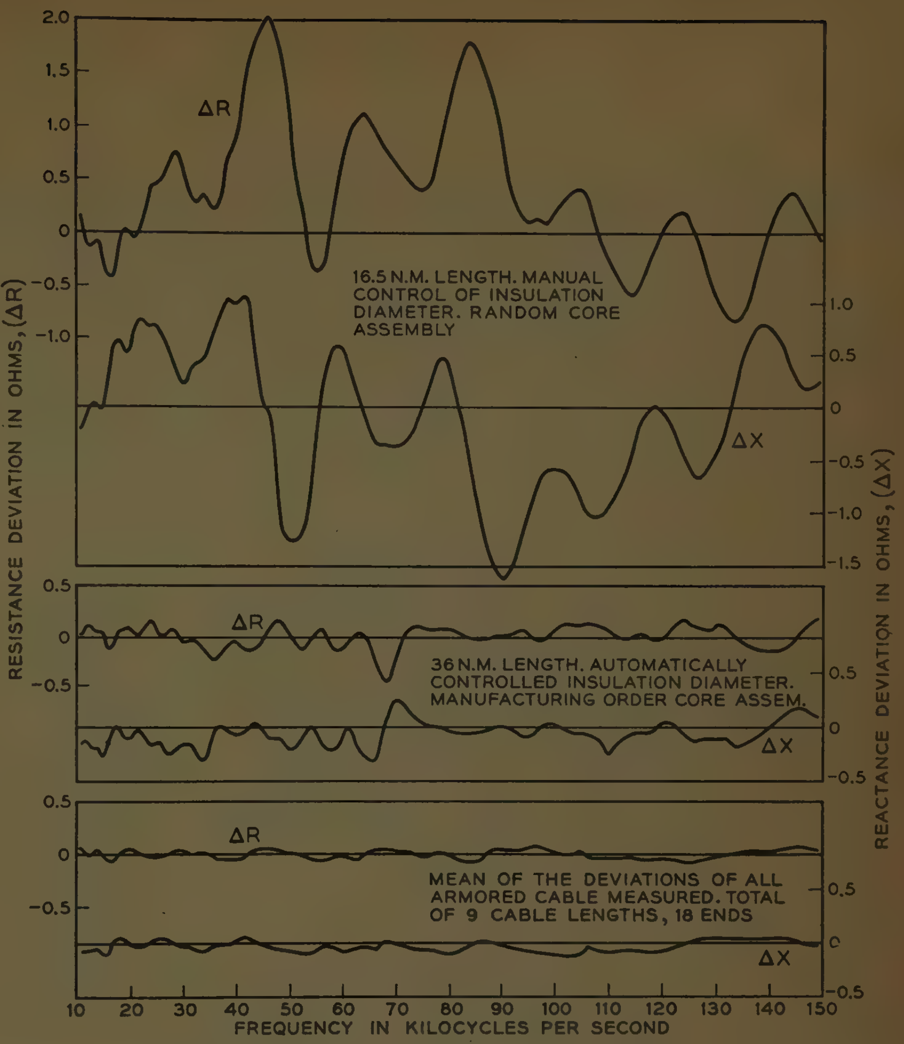


Figure 6. Impedance deviation of cable sections

After putting out mark buoys at strategic points and at intervals of about 12 nautical miles along the course of the cable, the Key West shore end of Number 5 cable was picked up at Sand Key and spliced to the cable in the tanks. Then 32 nautical miles of this cable were payed out, and the end buoyed at the point of final splice. The ship then proceeded to Havana and landed the manhole repeater which was spliced to the underground cable to the office. The ship then floated the end of the cable ashore on barrels with the aid of a line operated by a winch manned by Cuban Telephone Company personnel. As soon as the end reached shore it was spliced to the repeater, the barrels were cut off, the cable dropped to the bottom, and the cable on shipboard was payed out until the point of final splice was reached, where the end on board was spliced to the previously buoyed end to complete the connection between Key West and Havana.

The ship then returned to Havana, landed the end of Number 6 cable by means of barrels and winch line, and payed out cable to the point of final splice, which in this case was about four miles from Sand Key. The end of Number 6 at Sand Key was then picked up, a repeater spliced to it and to the end of the cable in the tank, and the latter was payed out to the point of final splice. Within a short time after completing this splice, insulation measurements had been completed on the two cables, the power supply was connected in to activate the repeaters, and conversation over the cable system took place.

Careful attention was given to the amount of slack payed out, that is, the excess of cable length over the actual distance traversed. This latter distance is usually determined by observing the length of a taut wire payed out continuously during the laying. In the absence of taut wire gear other methods had to be devised. Observations on buoys by radar and range finder provided almost continuous information regarding the position of the ship and gave satisfactory information on slack. The conditions for cable-laying between Key West and Havana are far from good. The Gulf Stream is swift and erratic. The velocity of the current at any particular point as indicated by the stream at the buoys was found to vary considerably over a fairly short period of time. As an indication of the degree of precision obtained by careful navigation of the ship, the final results show that in each of the cables the specified length was missed by only 0.2 nautical mile, which is quite an unusual achievement. Since the installation of the new system it has been subjected to comprehensive tests involving measurement of noise and intermodulation between channels as well as precise measurements at numerous frequencies of net loss of the repeatered cables at intervals of time. The system has proved to be very stable and has met the requirements laid down for it.

REFERENCE

1. The Future of Transoceanic Telephone—Thirty-Third Kelvin Lecture, O. E. Buckley. *Bell System Technical Journal* (New York, N. Y.), volume 21, July 1942, pages 1–19.

Electrical Essays

Motionally Induced Electric Fields—Part V

Relative Motion of Magnetic Field and Body

Jack, the physicist, is continuing his lectures to Alter Ego and his friends on the basic principles underlying dynamo-electric machines.

Jack is trying to determine the motional electric field induced in a moving iron bar. He has declared that the motional electromotive force, or $\mathbf{E}_{\text{mot}} \cdot \mathbf{ds}$, induced in a coil which is part iron and part copper and which is being translated in an otherwise uniform magnetic field, will be zero, thus declaring inoperative some extraordinary inventions of Alter Ego. However, Alter Ego had based his expectation of a nonzero motional electromotive force in such a coil in translation in an otherwise uniform magnetic field on the equation

$$\mathbf{E}_{\text{mot}} = \frac{1}{c}[\mathbf{v} \times \mathbf{B}] \qquad (1)$$

which Jack had said was universally valid. In this equation, up to this point, Jack had defined $\mathbf{v}$ as the velocity of the material of the moving body, in some suitably chosen material frame of reference.

Jack recognizes the contradiction between his statement of the universal validity of equation 1 and his statement of the inoperativeness of Alter Ego's inventions. He is now trying to resolve the dilemma by changing the meaning to be ascribed to $\mathbf{v}$ in equation 1.

Jack: "Perhaps the way out is to make $\mathbf{v}$ in equation 1 not represent the velocity of the iron bar relative to some material frame of reference which we arbitrarily say is at rest, but to make $\mathbf{v}$ represent the relative velocity of the iron bar and the magnetic lines of force.

"Thus, in Figure 1 we may regard the lines of magnetic force, *A*, *B*, *C*, and so forth, as at rest where they are remote from the iron bar. Then as the bar moves up to any line of force, the line of force will bulge out to meet it, as line *A* in Figure 1. At this bulge which is thus produced, the line of force is not at rest, but is advancing to meet the iron bar. This relative velocity of the bulge and bar increases, until the bulge hits the bar, as is shown for line *B* in Figure 1.

"After the line of force enters the iron, the bulge starts to straighten out, as at *C*. This straightening out of the bulge in the iron makes the lines of force in the iron move along in the same direction as that in which the iron bar is moving, so that the relative velocity of the bar and the magnetic lines is less than the velocity of the bar itself.

"The bulge is straightened out at *D*, but then develops in the opposite direction, keeping the same reduced velocity relative to the bar. At *E*, the line emerges from the iron, and snaps straight again through intermediate form *F*.

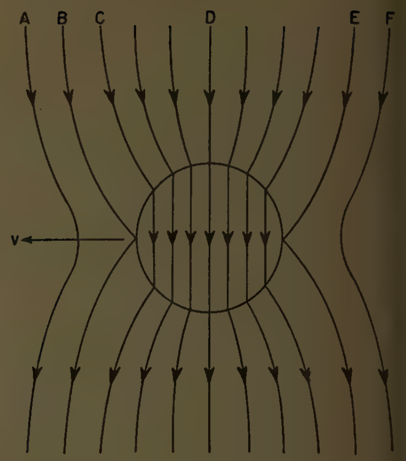


Figure 1. Converging field in a moving iron cylinder

"If $\mathbf{B}_0$ is the field strength remote from the bar, where the lines are stationary, and $\mathbf{B}$ is the magnetic field strength in the iron, and if $\mathbf{v}_0$ is the velocity of the bar, and if $\mathbf{v}$ is the relative velocity of the bar and the moving field lines in it, then

$$[\mathbf{v} \times \mathbf{B}] = [\mathbf{v}_0 \times \mathbf{B}_0] \qquad (2)$$

since each side of equation 2 gives the rate of cutting of lines of force by the bar. Hence, the motional field in the iron will be

$$\mathbf{E}_{\text{mot}} = \frac{1}{c}[\mathbf{v} \times \mathbf{B}] = \frac{1}{c}[\mathbf{v}_0 \times \mathbf{B}_0] \qquad (3)$$

which is the same as that for the copper bar."

Alter Ego: "Well, if you are going to interpret $\mathbf{v}$ in equation 1 that way, I concede that it will ruin my iron-copper coil commutatorless d-c generator. But what happens to my space ship and commutatorless d-c motor? Your universal equation for the mechanical force per unit volume on a body carrying current density $\mathbf{i}$ in a magnetic field $\mathbf{B}$ is

$$\mathbf{F}_m = [\mathbf{i} \times \mathbf{B}] \qquad (4)$$

"This equation does not have $\mathbf{v}$ in it at all. Therefore, the relative motion of the magnetic lines does not have any effect, so that with $\mathbf{B}$ twice as great, the force on the iron side of the coil will be twice as great as that on the copper side, and there will be a net force, not zero, tending to translate the coil."

(*To be continued*)

I think Jack will be able to take care of the mechanical forces. Can you, dear reader, also do so?

How about those relatively moving lines of magnetic force? Will Jack be able to get anywhere with that idea?

J. SLEPIAN
(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Answers to Previous Essays

Motionally Induced Electric Fields—Part IV. The following the author's answer to his previously published essay *EE, Feb '51, pp 159–60).*

As the author has observed so many times in the past these various essays, relative to any particular suitable ame of reference, there is but one electric field **E**, and also ut one **D**, one **H**, and one **B**, and these are the quantities hich enter into Maxwell's field equations. These vectors ay be defined in empty space through local observation of he forces on charged probes, placed in the empty space, y equation 3,[1] and may be defined within bodies stationary r moving through observation of the forces on charged robes within crevices in the bodies by equations 2 to ,[2] The charge and current densities, ρ and **i**, are then efined from the quantities **D** and **H** by equations 3 nd 10.[3]

Maxwell's field equations are not enough to fix or determine in a mathematical sense the various field quantities which we have defined operationally through observations n charged material probes in empty space. To get a athematically complete system we adjoin the constitutive quations of the various materials in question, which are etermined by experiment or otherwise.

If we know the constitutive equations for the matter of body at rest, then the principle of relativity enables us to etermine the constitutive equations for the body in a state f uniform motion. We merely make the transformation f the field quantities called for by relativity.[4] In this way, e obtained the constitutive equations for the glass of a lass slide bar.

$$=\epsilon\mathbf{E}+(\epsilon-1)\frac{1}{c}[\mathbf{v}\times\mathbf{B}] \tag{1}$$

$$=\mathbf{H}-\frac{\epsilon-1}{\epsilon}\frac{1}{c}[\mathbf{v}\times\mathbf{D}] \tag{2}$$

$$=\frac{1}{c}\mathbf{v}\rho \tag{3}$$

To deal with the iron slide bar, we similarly determine e constitutive equations for moving iron from the known uations for iron at rest, that is

$$=\sigma\mathbf{E}' \tag{4}$$

$$=0 \tag{5}$$

$$'=0 \tag{6}$$

$$=f(\mathbf{H}') \tag{7}$$

Making the substitutions of equations 1,[4] we get these uations:

$$-\frac{1}{c}\mathbf{v}\rho=\sigma\left(\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]\right) \tag{8}$$

$$-\frac{1}{c}\mathbf{v}\cdot\mathbf{i}=0 \tag{9}$$

$$+\frac{1}{c}[\mathbf{v}\times\mathbf{H}]=0 \tag{10}$$

$$-\frac{1}{c}[\mathbf{v}\times\mathbf{E}]=f\left(\mathbf{H}-\frac{1}{c}[\mathbf{v}\times\mathbf{D}]\right) \tag{11}$$

Neglecting higher powers of v/c than the first, we get that one of the constitutive equations of which we shall make use in this essay, namely

$$\mathbf{i}=\sigma\left(\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]\right) \tag{12}$$

Maxwell's field equations plus the constitutive equations just mentioned are sufficient for solving the two slide-bar problems which Alter Ego has presented to us. For this purpose it is convenient to use an integral of that Maxwell equation concerned with curl **E**, which is slightly more general than that given by Stokes theorem. Stokes theorem itself tells us that for any closed curve, lying wholly or partly in the matter of stationary or moving bodies or in empty space

$$\int\mathbf{E}\cdot d\mathbf{s}=-\int\int\frac{1}{c}\frac{\partial\mathbf{B}}{\partial t}\cdot d\mathbf{S} \tag{13}$$

In equation 13 the integral on the left side is taken round the closed curve. The integral on the right side is taken over any 2-sided surface bounded by the closed curve, and lying where it may, wholly or partly within stationary or moving matter.

Equation 13 refers to any particular closed curve with any bounded surface which we may arbitrarily select or construct at any particular instant of time. Let us now consider the temporal succession of such closed curves and bounded surfaces which we obtain by assigning an arbitrary continuous velocity **u** to the various points of the closed curve and bounded surface. **u** need have no relation to the velocity **v** of the matter through which the curve or surface may pass. **u** is a mathematical parameter arbitrarily assigned over the curve and surface of integration in matter or in empty space, wherever the curve or surface may lie.

At any particular instant of time, equation 13 applies for that particular instantaneous configuration of curve and surface of integration. Now add to both sides of equation 13 the quantity $\int\frac{1}{c}[\mathbf{u}\times\mathbf{B}]\cdot d\mathbf{s}$. We get

$$\begin{aligned}\int\left(\mathbf{E}+\frac{1}{c}[\mathbf{u}\times\mathbf{B}]\right)\cdot d\mathbf{s}&=\int\frac{1}{c}[\mathbf{u}\times\mathbf{B}]\cdot d\mathbf{s}-\int\int\frac{1}{c}\frac{\partial\mathbf{B}}{\partial t}\cdot d\mathbf{S}\\&=-\int\frac{1}{c}\mathbf{B}\cdot[\mathbf{u}\times d\mathbf{s}]-\int\int\frac{1}{c}\frac{\partial\mathbf{B}}{\partial t}\cdot d\mathbf{S}\\&=-\frac{1}{c}\frac{d}{dt}\int\int\mathbf{B}\cdot d\mathbf{S}\end{aligned} \tag{14}$$

That is, the integral of $\mathbf{E}+\frac{1}{c}[\mathbf{u}\times\mathbf{B}]$, where **E** and **B** are the one and only Maxwellian **E** and **B**, around any closed curve, the points of which move with arbitrarily assigned velocity **u**, is equal to $-1/c$ times the rate of change of the magnetic flux linked by the arbitrarily moving curve. We shall make frequent use of equation 14, so let us keep it in mind.

Let us now consider the two slide-bar problems. We shall confine our attention to the neighborhood of the plane of symmetry perpendicular to the slide bar at its middle, and we shall assume the bar long enough so that the effect of its ends will not disturb the 2-dimensional character of the field near the plane. That is, we shall assume that near the plane of symmetry, the magnetic vectors **H** and **B** are parallel to the plane, and that the electric vectors, **E** and **D**, and also **i**, are perpendicular to the plane, and that these vectors do not change in magnitude or direction as we move away in a perpendicular direction from the plane of symmetry.

Far enough away from the slide bar we assume that we have a uniform magnetic field, $\mathbf{H}=\mathbf{B}=\mathbf{B}_0$, and a uniformly zero electric field, $\mathbf{D}=\mathbf{E}=\mathbf{E}_0=0$. Within or near the slide bar, for either case, the magnetic and electric fields are altered and **B** and **E** may not be equal to $\mathbf{B}_0$ and $\mathbf{E}_0$ respectively. Consider the temporally changing rectangular path of integration constructed as follows, Figure 1.

Adjacent to or within the central part of the slide bar, draw a short path length, *AB*, parallel to the bar, and let *AB* move with the velocity **v**, keeping always in the same geometric relation to the slide bar. Draw the two path sides *AD* and *BC* parallel to each other and in the direction **v**. The final closing path side, *CD*, is parallel to *AB*, and is to be kept at rest. *AD* and *BC* are thus lengthening, and the area *ABCD* is increasing at the rate *vl* where *l* is the length of *AB* or *CD*.

Now apply the theorem of equation 14 to the closed path *ABCD*. At *CD*, we have $\mathbf{u}=0$, $\mathbf{E}=0$. *CD* therefore gives a zero contribution to the integral of equation 14. For sides *BC* and *AD*, **E** and $[\mathbf{u}\times\mathbf{B}]$ are perpendicular, and so these sides also give zero contribution. For side *AB*, which alone contributes to the integral, we have $\mathbf{u}=\mathbf{v}$, so that

$$\int_{ABCD} \mathbf{E}+\frac{1}{c}[\mathbf{u}\times\mathbf{B}]\cdot d\mathbf{s}=\left(\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]\right)\cdot\mathbf{l} \qquad (15)$$

where the meaning of the vector **l** is sufficiently self-obvious.

Now, since *AB* moves with velocity **v**, keeping always in the same position relative to the slide bar, the magnetic field configuration at that end of *ABCD* remains unchanging. The rate of change of the flux linked by *ABCD* will be its rate of increase of area, *vl* multiplied by $\mathbf{B}_0$, or $[\mathbf{v}\times\mathbf{B}_0]\cdot\mathbf{l}$. Applying equations 14 and 15, paying due attention to algebraic signs, we get this equation

$$\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]=\frac{1}{c}[\mathbf{v}\times\mathbf{B}_0] \qquad (16)$$

Now for the iron bar, we have from the constitutive equation

$$\mathbf{i}=\sigma\left(\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]\right)=\sigma\left(\frac{1}{c}[\mathbf{v}\times\mathbf{B}_0]\right) \qquad (17)$$

We see then that the current set flowing in the iron bar by its motion in the otherwise uniform magnetic field, $\mathbf{B}_0$, is entirely determined by its conductivity at rest and is independent of its magnetic properties. If the bar causes the magnetic field within it and in its neighborhood to be different from $\mathbf{B}_0$, then its motion **v** will cause an electric field **E** to be set up within it and in its neighborhood given by equation 16, and the current density remains given by equation 17.

We see then that Alter Ego's commutatorless d-c machines are inoperative, but we sympathize with him for being misled by the notion that there exists a "motional electric field." There is but one electric field, **E**, and Maxwell is its prophet!

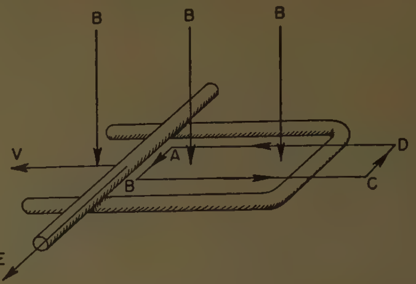


Figure 1. Path of integration, ABCD

We see also how the incorrect treatment of Lorentz' electron theory given by Jack could be corrected.

For the glass rod, if we define its polarization, **P**, by equation 18, and use the constitutive equation 1 and equation 16, we get

$$\mathbf{P}=\frac{1}{4\pi}(\mathbf{D}\quad\mathbf{E})=\frac{1}{4\pi}(\epsilon-1)\left(\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]\right)=\frac{1}{4\pi}(\epsilon-1)\left(\frac{1}{c}[\mathbf{v}\times\mathbf{B}_0]\right) \qquad (18)$$

The polarization then is the same as would be produced in the bar at rest by an electric field equal to $\frac{1}{c}[\mathbf{v}\times\mathbf{B}_0]$ although actually the moving glass bar will have in it a magnetic field differing slightly from $\mathbf{B}_0$ by equation 2.

J. SLEPIAN

(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

REFERENCES

1. Electrostatic Space Ship, J. Slepian. *Electrical Engineering*, volume 69, March 1950, page 248.
2. Motionally Induced Electromotive Force—Part I, J. Slepian. *Electrical Engineering*, volume 69, November 1950, pages 1025–6.
3. Polarization or Charge in a Dielectric? J. Slepian. *Electrical Engineering*, volume 69, September 1950, page 792.
4. Motionally Induced Electromotive Force—Part III, J. Slepian. *Electrical Engineering*, volume 70, February 1951, pages 161–2.

Three Impedances. The following is the author's answer to his previously published essay (*EE, Feb '51, p 160*).

From equations used to convert networks from star to delta, and from delta to star after substitutions and reductions, the following relationships are obtained:

$$Z_1^2=-Z_2^2=-Z_3^2 \qquad (1)$$

$$Z_2=-Z_3 \qquad (2)$$

These are satisfied by impedances that are equal in magnitude, one being real and positive, and the other two being conjugate imaginary impedances.

$Z_1=K$
$Z_2=jK$
$Z_3=-jK$

A. A. KRONEBERG (F '48

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Aging of Class-B Insulating Material in Nitrogen

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New studies have been made of the aging of Class-B insulating material in nitrogen, and it has been found that the insulations follow the same behavior rules in nitrogen as they do in air. However, the tests indicate Class-B material in nitrogen can be used in temperatures where the more expensive Class-H insulations were formerly used.

VERY LITTLE DATA have been published on thermal perform- nce of Class-*B* insulation ince the creation of the efinitions for such materials nd the establishment of their ermissible operating tem- eratures as set forth in the tandards of the American tandards Association and the AIEE.[1,2] Definitions of uch materials are very loose, and the long established ules for operating temperatures are vague.

By way of review, Class-*B* insulation materials are lefined as aggregates of inorganic materials, such as mica, lass, or asbestos bonded with organic resin. The resins ised in Class-*B* materials, although they are heat resisting, re Class *A* by definition. Nevertheless, such resins are tilized to give both mechanical and electrical properties o composite Class-*B* insulation. In contact with in- rganic materials, they apparently withstand higher emperatures than when in contact with cellulose, but it this essential organic bonding material which deteriorates ith time and temperature.

PREVIOUS WORK

MANY YEARS of tedious study on Class-*A* materials under oil have given answers as to life and laws of ging that are roughly confirmed by operating experience. he approach with Class-*A* materials[3] was through meas- red degradation of some mechanical property, usually ensile strength. No such background existed on Class-*B* aterials. A method of determining the probable life f various materials of this class was described by the uthors.[4]

It was then shown that the dielectric strength ecreased progressively and consistently with time and mperature and, hence, results obtained at high tempera- ures in short time could be extrapolated to low tempera- ures, and the governing laws, life versus time, determined uch as they could be for Class-*A* materials.[3] Since change dielectric strength is even more important fundamentally an change in mechanical strength, this method has been nployed for the further study of the aging of Class-*B* aterial in nitrogen gas.

NEW WORK

DATA ARE PRESENTED here on insulation, aged in nitrogen, subjected to temperatures in excess of esently established operating levels. From these data, extrapolation can be made to indicate anticipated life at any chosen operating temperature. The results shown here indicate the maximum life which can be expected from insulations when maintained continuously at a given temperature. In these tests, as with oil-sealed apparatus, there was no possibility of contamination by dirt or moisture absorption.

MATERIAL INVESTIGATED

Commercial grade of asbestos sheets
Thickness: 15 mils
Impregnant: Temperature-resisting phenolic resin
Cooling medium: Nitrogen at five pounds gauge pressure

Fiberglas Yarn
Thickness: 20 mils
Impregnant: Temperature-resisting phenolic resin
Cooling medium: Nitrogen at five pounds gauge pressure

These materials are representative of some of the Class-*B* insulation used as winding material, insulating barriers, and cylinders in electric equipment. The curing time and temperature for test pieces are those recommended by the manufacturer for curing the heat-resisting phenolic resin used. The test pieces then were subjected to final life test.

TESTING TECHNIQUE

THE SAMPLES were tested in a gas chamber as shown in Figures 1 and 2. Reference should be made to the previous paper[4] for details of sample preparation and complete testing procedure and measurement technique. Insulated electrodes leading from the gas chamber allow the application of current for supplying internal heat and permit temperature measurements and dielectric test at operating temperatures. The gas pressure was maintained at five pounds gauge to insure the purity of the

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Full text of paper 51-69, "Aging of Class-*B* Insulating Material in Nitrogen," recommended by the AIEE Committees on Rotating Machinery, Standards, and Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

H. C. Stewart and L. C. Whitman are with the General Electric Company, Pittsfield, Mass.

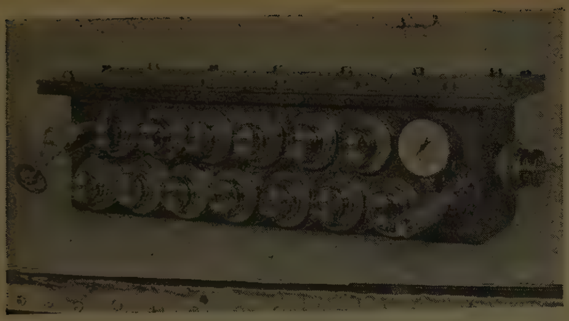

Figure 1. Complete gas chamber for testing insulation pieces in nitrogen

Figure 2. Gas chamber for testing insulation pieces in nitrogen with cover removed

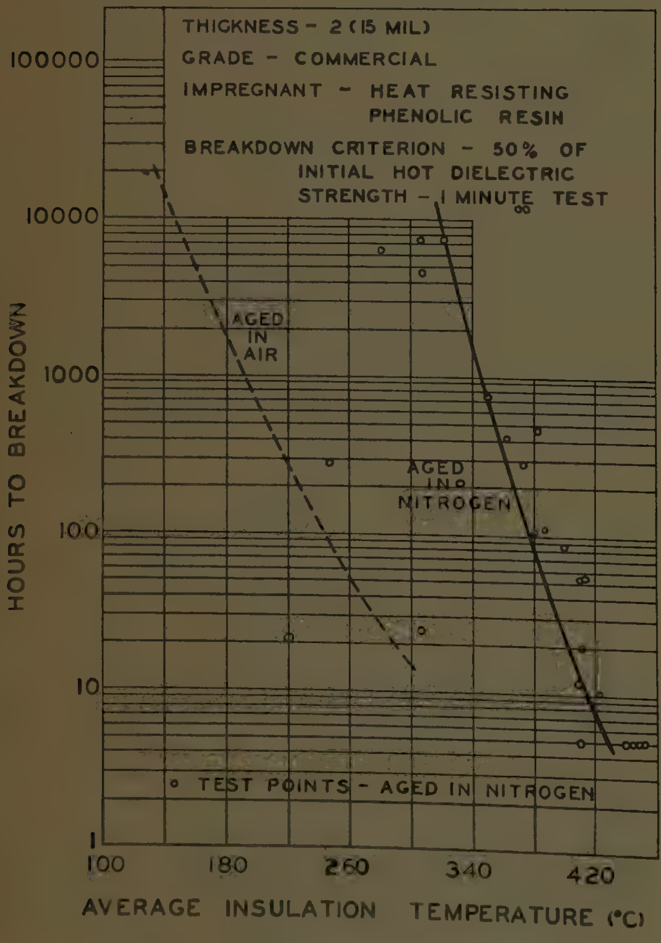

Figure 3. Life characteristics of asbestos sheets

nitrogen gas by preventing the entrance of contaminants into the gas chamber.

CRITERION OF LIFE OF INSULATION

As formerly proposed,[4] the end of expected life of insulation when operated in a gas medium can be considered as reached when its final hot dielectric strength has decreased to 50 per cent of the initial value with a given temperature maintained. This is an entirely arbitrary selection but may well represent the end of life when the more severe operating conditions such as lightning, switching surges, and short circuit are considered.

RESULTS

The solid-line graph shown in Figure 3 gives the life characteristics of impregnated asbestos sheets aged in nitrogen gas. It is to be noted that this graph is plotted with the hours to breakdown on the logarithmic vertical axis, but that the average insulation temperature is plotted on the uniform horizontal axis with an evenly divided scale. For a convenient reference, the aging of samples of the same material in air is shown on Figure 3 as the dotted line at the left of the graph.[4] The results of these data are of great interest and show that Class-*B* insulation operated in nitrogen gas can give comparable life at considerably higher temperature than is permissible for such material in air. Tests are incomplete but life characteristics of impregnated glass yarn seem to follow the same pattern as the tests on asbestos. In other words, much longer life can be expected of glass yarn aged in nitrogen. As was to be expected where resin is the dominating factor, higher initial dielectric strengths were obtained in nitrogen. This is no doubt due to slower oxidation and the exclusion of moisture and other contaminants.

CONCLUSIONS

1. The method of evaluating the life characteristics of Class-*B* material operating in nitrogen yields results consistent with the data obtained on such materials in air.
2. The so-called "degree rule" (degrees increase in temperature to reduce life 50 per cent) for asbestos aged in nitrogen is approximately 10 degrees centigrade in the temperature range investigated.
3. The data indicate that Class-*B* materials operated in nitrogen can be safely operated at the 180-degree-centigrade temperature now assigned to Class-*H* materials. This is very important since it permits the building of completely sealed electric equipment with the less expensive Class-*B* material in place of Class-*H* material.
4. These data would indicate a need for recognition in standards of the influence of the surrounding medium on the life of the present Class-*B* insulations.

REFERENCES

1. Standards for Transformers, Regulators, and Reactors. *C57.11-1948*, American Standards Association, New York, N. Y., 1948.

2. Introduction to AIEE Standards. AIEE *Standard Number 1*, June 1947.

3. Preliminary Report on Laboratory Aging Tests on Class-*A* Insulation, AIEE Committee Report. AIEE *Transactions*, volume 66, 1947, pages 879–83.

4. Aging Characteristics of Dry-Type Transformer Insulation at High Temperatures. H. C. Stewart, L. C. Whitman. AIEE *Transactions*, volume 67, 1948, pages 1600–7.

NSTITUTE ACTIVITIES

lany Exciting Tours Planned for AIEE Southern District Meeting

The Southern District Meeting is being d this year in Miami Beach, Fla., from ril 11 through April 13. Headquarters l be at the Macfadden-Deauville Hotel; 500 people are expected to attend this eting, nearby hotels will be used also.

The Southern Regional Conference of the uminating Engineering Society is being d April 9 and 10 in Miami Beach, with adquarters at the Atlantis Hotel, Miami ach, and Institute members who are erested in this conference can plan to end it in conjunction with the AIEE uthern District Meeting.

TENTATIVE TECHNICAL PROGRAM

The technical sessions will start promptly 8:30 A.M. and continue to noon on ril 11, 12, and 13. Dr. H. H. Sheldon of University of Miami has arranged for out 50 papers which are divided into ee subject groups: 1. Power Generation d Distribution; 2. Electric Power Utiliion; and 3. Modern Developments. o sessions will be run concurrently. pers are being received from many states, presenting all of the large electric equipnt manufacturers. There will be a good resentation from engineering schools. e technical program will appear in the ril issue of *Electrical Engineering*.

INSPECTION TRIPS

The Cutler Steam Electric Station of the rida Power and Light Company is ated on Biscayne Bay about nine miles th of Miami. The plant has a total ability of 80,000 kw and is unique in t it is outdoor-type construction. The est unit is 50,000-kw capability with m conditions of 1,250 pounds per square h at 900 degrees Fahrenheit. The tors will be conducted through the entire nt, with the various functions explained members of the plant personnel. The rn trip to the hotel will be made via the versity of Miami campus and Coral les.

astern Air Lines. An opportunity to the home of Eastern Air Lines Operas Base in Miami will be afforded those nding the meeting. On this tour, nbers will see the International Airport , particularly, will watch tests performed uch shops as Engine Overhaul, Engine essories, Cabin Supercharger Section, hine shops, radio equipment, instrument haul, and engineering shops. Upon ing the maintenance checks, visitors will a 30-minute flight over greater Miami 4-engine air transport as guests of ern Air Lines. Over the ship's intermunication system, places of interest be pointed out.

he United States Weather Bureau and ision Station WTVJ will be the points terest on another tour. The Weather Bureau atop the Vocational High School Building utilizes the latest instruments and radar for tracking hurricanes. These will be explained, together with a demonstration of the most recent developments in automatic electronic weather report instruments. The tour will proceed to Television Station WTVJ located on the roof of the Everglades Hotel in Miami. Here the members will see and hear about a complete modern transmitter. The tour then will move to the station studios in the Wometco Building where the latest instruments and equipment are used to produce video shows unassisted by any network hookup. A few of the visitors will have an opportunity to be interviewed and televised.

SIGHT-SEEING TOURS

Sight-Seeing Tour on Biscayne Bay. This is a must when visiting greater Miami. The many man-made islands scattered in the bay form waterways lined with beautiful homes. While cruising on South Bay, the members will see Virginia and Biscayne Keys, the only remaining virgin land in the area. These Keys are at the head of the famous line of Florida Keys extending south to Key West. The $16,000,000 Deering Estate, the Rickenbacker Causeway, the Mercy Hospital, and the historical Cape Florida Lighthouse will be seen.

The Greater Miami Tour by air-conditioned, glass-top busses will afford members 3½ hours and 50 miles of travel through Miami, Miami Beach, Hialeah, Miami Springs, Coral Gables, Coconut Grove, and other sections of Dade County. On this trip opportunities will be afforded to take pictures where movies are made and capture a lasting record of the trip to greater Miami. At such places as the Venetian Swimming Pool, Wheeler Estate, and Hialeah Race Track, the tour will be guide-conducted and members given a comprehensive picture of these specially selected points of interest. The Sausage Tree, English Village, Chinese Village, French Village, the pink flamingos, Eastern Air Lines Terminal, Alligator Farm, and the University of Miami also are included in this tour.

RECREATIONAL PROGRAM

The Bayshore and Normandy Shores Golf Courses are open to those attending the meeting with no green-fee charges. Arrangements for many beautiful sight-seeing trips by bus or boat, as well as bay-bottom and Gulf Stream fishing trips, can be made when registering at meeting headquarters. Also, postmeeting tours to either Nassau in the Bahamas or Havana, Cuba, by boat or air are available at headquarters.

SOCIAL PROGRAM

A luncheon is planned for April 11, and all delegates are expected to attend and hear the various speakers, possibly including AIEE President LeClair. This same day there will be a social get-together from 6 to 7 P. M., and a buffet supper at 7 P. M. followed by a spectacular water show.

A banquet will be held April 12, at which Student awards will be presented, followed by dancing in the ballroom.

Arrangements have been made so that the ladies may play bridge and canasta for prizes while the technical sessions are in progress. The Macfadden-Deauville Cabana Club's pool and ocean beach are available for swimming and sun bathing. Conducted sight-seeing trips to the Fairchild Gardens, Rare Bird Farm, and Parrot Jungle are available. Shopping on Miami Beach's world-famed Lincoln Road also will be enjoyed by the ladies.

Future AIEE Meetings

Southern District Meeting (*page 259*)
Macfadden-Deauville Hotel, Miami Beach, Fla.
April 11–13, 1951
(*Final date for submitting papers—closed*)

North Eastern District Meeting (*page 259*)
Hotel Syracuse, Syracuse, N. Y.
May 2–4, 1951
(Final date for submitting papers—*closed*)

Great Lakes District Meeting (*page 260*)
Loraine Hotel, Madison, Wis.
May 17–19, 1951
(*Final date for submitting papers—closed*)

Summer General Meeting (*page 261*)
Royal York Hotel, Toronto, Ontario, Canada
June 25–29, 1951
(*Final date for submitting papers—March 27*)

Pacific General Meeting
Multnomah Hotel, Portland, Oreg.
August 20–23, 1951
(*Final date for submitting papers—May 21*)

Fall General Meeting
Hotel Cleveland, Cleveland, Ohio
October 22–26, 1951
(*Final date for submitting papers—June 22*)

North Eastern District Meeting to Be Held in Syracuse May 2-4

The 1951 AIEE North Eastern District Meeting will be held May 2–4 in Syracuse, N. Y. Headquarters will be at the Hotel Syracuse. Reservations have already been made to provide ample room accommodations for those members attending. Room reservation cards will be forwarded with the mailed announcement, which is sent to all members residing in District Number 1 (North Eastern).

The technical program is practically complete. However, current events may cause some changes in the final program. The following is a brief summary:

WEDNESDAY, MAY 2

Two sessions are contemplated for the morning period, one on the subject of "Air Conditioning," which will include papers on motors, application of air conditioning, with emphasis on power supply requirements.

The second session will cover "Cable and Street Lighting." Papers will be presented by a utility operating man, a fixture manufacturer, and a cable manufacturer, covering problems encountered in street and highway lighting, after which a general panel discussion will be held.

A luncheon meeting will be held Wednesday noon, followed by a round-table presentation by eminent authorities on "The Assignment and Development of the Engineer as a Professional Man."

THURSDAY, MAY 3

Two parallel day-long sessions will be held, one on "Steam Electric Power Generation" during which a paper will be presented giving the first published operating data on the new reheat machines recently placed in operation at the Dunkirk Steam Station of the Niagara Mohawk Power Corporation.

The second session, which will be held at Electronics Park, the headquarters of the General Electric Electronics Department, will cover "Electronics and Communications." A series of papers will be presented on developments and use of electronics in the communication and utility fields.

FRIDAY, MAY 4

Because many of the student prize papers in both the undergraduate and graduate field are deserving of greater encouragement and recognition on the part of the practicing Institute members, the Friday morning technical program will be devoted completely to the presentation of two parallel sessions of student papers.

INSPECTION TRIPS AND ENTERTAINMENT

Inspection trips are planned for both Thursday and Friday. Scheduled so far are a visit to Electronics Park, security regulations permitting, Carrier Corporation, and Syracuse University.

The District Executive Committee will hold a dinner meeting on Tuesday, May 1. A stag smoker will be held May 2, and a mixed banquet May 3. Entertainment is being planned for both these events.

A most attractive program for the visiting ladies has been arranged, including luncheon, dinner, bridge parties, shopping trips, and a visit to the Syracuse China Company plant and store.

Great Lakes District Meeting to Be Held in Madison, Wis.

The 1951 AIEE Great Lakes District Meeting, which is to be held in Madison, Wis., May 17–19, promises to be filled with a wide variety of technical papers, all of which will be integrated with the fundamental theme, "Applications of Fundamental Theory," adopted by the general committee at its first meeting. Headquarters for the meeting will be the Loraine Hotel.

The State House at Madison, Wis. The 1951 AIEE Great Lakes District Meeting is being held May 17–19 in Madison

Madison, the capital of Wisconsin, is not only headquarters for all state agencies and several public electric and communication utilities, but is the home of the University of Wisconsin, the Forest Products Laboratory, and machine tool and special manufacturing industries. There is ready access to recreational areas, to highly industrial areas, and to numerous small colorful communities inhabited by nationalities who retain many old customs.

PROGRAM

The technical program will have complete coverage of the wide field of fundamental applications encountered in electrical engineering. T. J. Higgins, Chairman of the Technical Program Committee of the 1951 Great Lakes District Meeting, reports very satisfactory progress in arranging the program, and stated that the response to the request for papers is gratifying.

The Students' program is arranged in a way that will permit the maximum number of contacts with the practicing engineers who will attend the meeting. Students will be included in the various luncheons and the banquet. Some separate sessions for the students are being planned; they will be held on the University of Wisconsin campus, which is close to meeting headquarters. John Baird is Chairman of the Student Activities Committee.

The Entertainment and Sports Committee, under the chairmanship of G. Ansel,
is planning to have the luncheons at meeti
headquarters, which will allow the ma
mum time for the entertainment the co
mittee has planned. The banquet
Thursday evening, May 17, will be held
Memorial Union on the University of W
consin campus.

The Inspection and Transportation Co
mittees, under the chairmanships of I.
Hesse and F. D. Mackie, not only ha
arranged inspection trips to points of inter
in Madison but will be available to arran
for special trips which delegates may wi
to make.

A program for the ladies is being plann
by Mrs. W. T. Stevens and her committee.

HOTEL RESERVATIONS

Members planning to attend the Gre
Lakes District Meeting are urged to ma
hotel reservations early. Blocks of roo
have been set aside at the Loraine and Pa
Hotels. There is a constant demand
rooms and, if early reservations do
meet expectations, it will be difficult to h
them. The Loraine Hotel will be meeti
headquarters, and all regular meetings
be held there. The Park Hotel is close
as are also the Edgewater and Belm
Hotels. Some tourist accomodations
available, and if this type of accomodat
is desired, E. J. Kallevang, Chairman of
Registration and Housing Committee, m
be contacted.

Requests for reservations can be ma
by writing directly to the hotels or to E.
Kallevang, Chief Engineer, Wisconsin Po
and Light Company, 122 West Washingt
Avenue, Madison 1, Wis.

GENERAL COMMITTEE

Plans for the meeting have been ma
by a general and special committee un
the chairmanship of Carl C. Crane
Madison. Other officers of the general co
mittee are: Harold A. Petersen, *Vice-Cha*
man; W. T. Stephens, *Secretary;* and J.
Hafstrom, *Treasurer*—all of Madison, Wis.

The general committee which determi
the general policies and passes on many
the details of the meeting has been cho
from all parts of the Great Lakes Distri
The committee members are: H. C
Detroit, Mich.; C. D. Malloch, Jacks
Mich.; I. B. Baccus, East Lansing, Mic
A. H. Lovell, Ann Arbor, Mich.; C.
Parks, Indianapolis, Ind.; D. D. Ewi
Lafayette, Ind.; Eric T. B. Gross, Chica
Ill.; J. F. Calvert, Evanston, Ill.; J.
Ryder, Urbana, Ill.; M. S. Coover, Am
Iowa; H. S. Dixon, Fargo, N. Dak.; H.
Hartig, Minneapolis, Minn.; J. F.
Douglas, Milwaukee, Wis.; and W. Rich
West Allis, Wis.

Members of the Institute who are Registered Professional Engineers

Attention has been called by the Chairman of the Committee on Registration of Engineers, Elgin B. Robertson, to the fact that there are a great many more registered professional engineers who are members of the Institute than is indicated in the 1950 Year Book. When Year Book cards are received, please be sure to fill in all information requested and return the cards. Do not fail to check the question, "Are you a registered professional engineer?"

Expense Awards from Member
for-Life Fund to Student Winn

The attention of Student members of
Institute is called to the annual Memb
for-Life Expense Awards which are m
available by the Members-for-Life of
Institute who voluntarily continue to
the regular dues beyond the time at w
they became exempt for life.

These awards are the payment of the
penses of the winners of the District Bra

r Prizes from their home towns to the
mer General Meeting of the Institute,
hich they present their papers on the
lar technical program of the meeting.
awards are available to the even-
bered Districts in the even-numbered
and to the odd-numbered Districts in
odd-numbered years.

e expenses are paid in the form of an
vance of 13 cents per mile, one way,
00 miles or less, and 10 cents per mile,
way, for the remaining distance of the
plus a reasonable maintenance allow-
per day for the official duration of the
ting.

is the hope of the national and District
ers of the Institute, and especially the
bers of the Members-for-Life Fund
mittee, that this additional award will
ulate interest in the Branch Paper Prize
greatly increase the number of con-
nts for the Prize.

Summer General Meeting Be Held in Toronto, Canada

he AIEE Summer General Meeting will
eld June 25 to 29 inclusive at the Royal
Hotel, Toronto, Ontario, Canada.
iew of the success of the meeting in
nto in 1941, it is anticipated that there
be a large attendance this summer.
General Meeting Committee under the
rmanship of Mr. O. W. Titus, Canada
and Cable Company, Limited,
nto, has been holding active meetings
the early fall and has planned an
nsive schedule of inspection trips, in
tion to the regular full program of
nical sessions.

e highly industrialized district of
ral Ontario, in which Toronto is located,
rto committed to an electrical supply
5 cycles per second, is now actively
ged in standardization to 60 cycles.
program of frequency changeover is
forward concurrently with extensive
opments of the capacity of power
ation and transmission facilities in-
ng numerous new central stations both
- and steam-powered. In addition, at
resent time in Toronto, the construction
der way of an important and fully
rn subway and open-cut electric rapid
t system. There is much which would
st the electrical engineer in the Toronto

e Entertainment and Sports Com-
e has prepared a comprehensive pro-
to occupy the leisure hours free from
ical activity, which will include an
sting and varied schedule for the
consisting of visits to Casa Loma,
nto's famous Castle on the Hill, Hart
at the University of Toronto, and the
Canadian Yacht Club.

e attention of the members is drawn to
act that the Sunday following the
letion of the meeting is a holiday in
da, which will be celebrated on
ay, July 2; and Wednesday, July 4,
course, Independence Day in the
d States. It is felt that many will take
tage of these additional holidays to
their trip to include a visit to the
on districts of Muskoka and the
ian Bay, which are within an easy
ay's drive from Toronto and offer unlimited facilities for swimming, fishing, and boating.

HOTEL ACCOMMODATIONS

Rooms have been set aside at the Royal York and King Edward Hotels for the convenience of the members attending. Applications for reservations should be made directly to the hotel of choice. Room rates for these two hotels are as follows:

Royal York Hotel (Meeting Headquarters)	**Rates Per Person**
Single room	$ 6.50 to $ 8.00
Parlour-bedroom	9.50 to 10.00
Double room	5.25 to 6.00
Parlour-bedroom	6.75 to 7.00
	Rates Per Suite
Suites—single occupancy—bedroom and sitting-room	16.00 to 26.00
Suites—double occupancy—bedroom and sitting-room	20.00 to 31.00
King Edward Hotel	
Single room, bath (1 person)	5.00 to 6.50
Double room, double bed, bath (2 persons)	8.50 to 10.00
Double room, twin beds, bath (2 persons)	9.00 to 10.00
Two connecting rooms (3 persons)	13.50 to 16.50
Two-room suites—single occupancy	12.00 to 15.00
Two-room suites—double occupancy	15.00 to 18.00
Three-room suites—single occupancy	18.00 to 36.00
Three-room suites—double occupancy	24.00 to 36.00

Official Nominees Announced for 1950 AIEE National Election

F. O. McMillan, Head of the Electrical Engineering Department, Oregon State College, Corvallis, Oreg., was nominated for the AIEE presidency by the Nominating Committee at its meeting held in New York, N. Y., January 24, 1951. Others named on the official ticket of candidates for the Institute offices that will become vacant August 1, 1951, are:

For Vice-Presidents:

J. C. Strasbourger, Supervising Engineer, Electrical Department, Cleveland Electric Illuminating Company, Cleveland, Ohio (Middle Eastern District, number 2)

J. D. Harper, Assistant District Power Manager, Aluminum Company of America, Alcoa, Tenn. (Southern District, number 4)

F. W. Norris, Professor and Chairman, Electrical Engineering Department, University of Nebraska, Lincoln, Nebr. (North Central District, number 6)

N. M. Lovell, Electrical Superintendent, Tucson Gas, Electric Light and Power Company, Tucson, Ariz. (Pacific District, number 8)

W. R. Way, General Superintendent, Generation and Transmission Department, Shawinigan Water and Power Company, Montreal, Quebec, Canada (Canada District, number 10)

For Directors:

F. R. Benedict, Manager, Industry Engineering Departments, Westinghouse Electric Corporation, East Pittsburgh, Pa.

R. F. Danner, Manager, Engineering and Construction Department, Oklahoma Gas and Electric Company, Oklahoma City, Okla.

D. D. Ewing, Head, School of Electrical Engineering, Purdue University, Lafayette, Ind.

For Treasurer:

W. I. Slichter, Professor Emeritus, Electrical Engineering, Columbia University, New York, N. Y.

The Nominating Committee, in accordance with the Constitution and Bylaws, consists of 15 members, one selected by the executive committee of each of the ten geographical Districts, and five selected by the Board of Directors from its own membership.

The Constitution and Bylaws of the Institute require publication in *Electrical*

The Royal York Hotel, headquarters of the 1951 Summer General Meeting, is shown at the left of the picture, with Union Station directly across the street, and the King Edward Hotel in the background

Engineering of the nominations made by the Nominating Committee. Provision is made for independent nominations as indicated in the following excerpts from the Constitution and Bylaws:

Constitution: Section 31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the Secretary when and as provided in the Bylaws; such petition for the nomination of Vice-Presidents shall be signed only by members within the District concerned.

Bylaws: Section 22. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with Article VI, Section 31 (Constitution), must be received by the secretary of the Nominating Committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the Nominating Committee in accordance with Article VI of the Constitution and sent by the Secretary to all qualified voters on or before April 15 of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

A list of members of the Nominating Committee appeared in the February issue of *Electrical Engineering*, page 166.

To enable those Institute members not acquainted personally with the nominees to learn something about their engineering careers and their qualifications for the Institute offices to which they have been nominated, brief biographical sketches are scheduled for inclusion in the "AIEE Personalities" columns of the April issue.

Second AIEE-IRE-NBS Conference on High-Frequency Measurements Held

That the radio-frequency portion of the spectrum is in a state of expansion was evidenced at the second conference on High Frequency Measurements held in Washington, D. C., January 10–12, 1951, which was attended by 549 engineers from all parts of this country and Canada. The technical program consisted of four sessions on different categories of measurements and an evening demonstration session together with inspection trips during the day. This conference was held in Washington as a part of the Semicentennial celebration of the National Bureau of Standards. The Joint AIEE-Institute of Radio Engineers (IRE) Committee on High Frequency Measurements, the AIEE Committee on Instruments and Measurements, the IRE Professional Group on Instrumentation, and the National Bureau of Standards co-operated in organizing the conference.

After registration at the Hotel Statler, members of the conference were invited to the Bureau of Standards where open house was held on Wednesday morning. Here the guests were shown the research and experiments being conducted in magnetism and electricity towards the goal of establishing various constants with a greater accuracy.

TECHNICAL SESSION I

F. J. Gaffney, Polytechnic Research and Development Company, presided over the opening session at the Department of the Interior Auditorium, where all the technical sessions were held. He introduced Dr. E. U. Condon, Director of the National Bureau of Standards, who spoke on "The Impact of High Frequency Measuremen on Research Development." Doctor Co don outlined some of the research problen being conducted currently and told ho measurements in the high-frequency regio were affecting them. He emphasized th increasing importance of such measuremen in the future.

The first paper of the session, which w devoted to the measurement of frequen and time, was presented by Harold Lyon National Bureau of Standards, and entitle "Program for Atomic Frequency and Tim Standards—A Survey." This paper covere a survey of the National Bureau of Standar (NBS) program on atomic clocks an oscillators, and figures were given for nois limited resolving power for gases, includin ammonia and oxygen, for atomic beam and for nuclear absorption. These we followed by a discussion of the potenti applications including measurements of ear rotation, comparison of atomic time and th mean sidereal year, and a millimeter-ban interferometer driven by an atomic clock f basing both time and length standards o one spectrum line.

B. F. Husten, National Bureau of Stan ards, read his paper, "Improved NB Ammonia Clock," which described how th absorption line of ammonia is utilized control a quartz-crystal oscillator an frequency multiplier chain by means of servo system, which is designed to corre the drift of the oscillator without impairin its normal short time stability. Circuit d tails and performance figures were given f the clock.

"The Stabilization of a Microwave Osci lator with an Ammonia Absorption Lin Reference" was given by E. W. Fletcher an S. P. Cooke, Cruft Laboratory, Harvar University, and read by the former. Th paper was primarily concerned with th problem of stabilizing a microwave oscillat on the 23,870-megacycle absorption line ammonia gas. Means for improving th stability were described together wi experimental results. Then the feedba loop as a servomechanism was analyzed wi a discussion of its design and operation. Th use of a spectral absorption line as a frequen reference and the design of the Cruft stabiliz were discussed.

L. E. Norton, Radio Corporation America (RCA) Laboratories, present "Performance of Oscillators Frequency Co trolled by Gas Absorption Lines." Over- stability of a frequency-controlled oscillat is specified by three factors: original fr quency stability of the uncontrolled oscill tor, stability of a standard frequency deriv from an absorption line, and other fact related to comparison circuit-servo cont loop elements. Stabilized oscillator p formance was predicted by calculating t error magnitude introduced by each of th causes and details of these effects were c scribed for several circuits.

Walter Gordy, Duke University, read paper on "Millimeter Wave Measuremen which included methods of generati detecting, and measuring microwaves the range of 30,000 to 150,000 megacy

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Lehigh Valley Section Meets in Hazleton, Pa.

Silas F. Clark of the Civil Aeronautics Administration, Washington, D. C., addressed members of the AIEE Lehigh Valley (Pa.) Section at a dinner meeting in Hazleton, Pa., January 12; his subject was "All Weather Aids to Air Navigation and Traffic Control." R. H. Wilcox, senior electrical engineering student, Lafayette College, presented a paper on "Very High Frequency Omnidirectional Radio Range." Left to right, seated, are: Mrs. Silas F. Clark, District Manager R. E. Edmunds, Mrs. R. H. Wilcox. Left to right, standing, are: Vice-Chairman D. A. Campbell, Jr., Silas F. Clark, R. H. Wilcox, Chairman G. M. Keenan, and Vice-Chairman H. E. Charles

l spoke on how they provide suitable quency standards for the calibration of ity wavemeters. He discussed the milli-ter-wave absorption of oxygen, carbon noxide, and other gases.

'Quartz Crystal Frequency Standards'' ; presented by W. D. George, National reau of Standards. This covered the formance of low-frequency quartz-crystal onators and oscillators which are used maintaining the national standard of quency and time intervals. Problems of tribution of the standard by radio broad-t were discussed.

. W. Warner, Bell Telephone Labora-ies, read "High Frequency Crystal Units Primary Frequency Standards" in which told how stabilities of one part in 100,-),000 per month had been achieved with stal units for primary frequency standards the 3- to 20-megacycle range, these being racterized by high Q and low capacitance the equivalent electric circuit.

TECHNICAL SESSION II

R. A. Braden, RCA Laboratories, was the airman of the Thursday morning technical sion devoted to measurement of impedance. e first of three papers covering precision asurements was given by N. E. Beverly, erry Gyroscope Company, entitled "In-ction Point Method of Measuring Q at ry High Frequencies." The method cribed determines the inflection points of esonance curve by a null indication and Q is found only as a function of the fre-ency at which these nulls occur. This oad method can be used to locate the lection points of lumped constant circuits, nsmission lines, and cavities functioning microwave frequencies.

The second paper, "A Precise Sweep quency Method of Vector Impedance asurement," was presented by D. A. berg, Bell Telephone Laboratories. The pedance of a 2-terminal network can be ned completely by the insertion law and se shift it produces when inserted between wn sending and receiving impedances. ances in precise wide-band phase and smission measuring circuits have per-ted practical use of this principle. These uits are free from zero correction, as the suring frequency is changed which in specific circuit can be swept continually n 0.05 to 20 megacycles while data can recorded automatically with accuracies to ±0.25 per cent. Reactive and re-ve impedance components are read ctly from a simple graphical chart in ch frequency is not a parameter.

The title of the next paper was "Precision xial Resonance Line for Impedance asurement" and was presented by H. E. ows with R. E. Hamilton and W. E. n of the National Bureau of Standards M. S. Wong, Aircraft Radiation oratory, Wright Field, as coauthors. As of a program to develop standards of surements of electrical quantities at high frequencies, an instrument has constructed with which precise measure-ts can be made by a resonance-curve hod. Sources of error in measurement e with this "Chipman" type line were ussed, and methods presented for evaluat-the magnitudes of those errors which ot be made negligible by use of the er techniques. A theoretical analysis of rrors was presented in a form which can be applied directly to the determination of the accuracy of impedance measurements made with the line.

AIEE President LeClair, Dr. E. U. Condon, Director of the National Bureau of Standards, IRE President I. E. Coggeshall, and Dr. Ernst Weber, Chairman of the Joint AIEE-IRE Committee on High Frequency Measurements, are shown at the ceremony in which scrolls were presented to the Bureau in recognition of its 50th anniversary

The second half of the session was devoted to rapid measurements, the first paper of which was entitled "A 2,600–4,000 Megacycle VSWR Measuring Set" and presented by S. F. Kaisel, RCA Laboratories, and J. W. Kearney, Airborne Instruments Laboratory, and read by the former. A voltage-standing-wave-ratio (VSWR) measuring unit was described which presents on an oscilloscope a quantitative picture of the VSWR looking into a waveguide or coaxial line element over the frequency range of 2,600–4,000 megacycles. The unit consists of a mechanically swept reflex klystron oscillator as a radio-frequency signal source which feeds a waveguide Magic Tee as the measuring element. The unbalance of the Magic Tee bridge is presented on an oscilloscope and means are provided for calibrating this oscilloscope directly in terms of VSWR.

A. E. Laemmel, Polytechnic Institute of Brooklyn, presented "Measurement of Waveguide and Coaxial Line Impedances with a Circular Waveguide." This is done by rotating a pickup loop in a circular waveguide which is joined to the waveguide or coaxial line containing the unknown impedance. The rotary variation of voltage induced in the loop can be used to measure impedance in the same way that the linear variation of voltage picked up by the probe of a slotted section is used, since both patterns are the same under suitable conditions.

"A Survey of Microwave Dielectric Techniques for Small Liquid and Solid Samples" was presented by George Birnbaum, National Bureau of Standards. The author surveyed the theory and application of cavity systems suitable for measuring the microwave dielectric properties of liquids and solids in the form of small-diameter cylindrical samples. The equations connecting dielectric constants with resonance frequency and loss factor with Q for such samples suitably located in a TM$_{010}$—cylindrical cavity or a TE$_{10}$—rectangular cavity and apparatus for measuring these cavity parameters were described.

PRESENTATION OF SCROLLS

The morning session on Thursday was followed by a luncheon at the Hotel Statler, at which Ernst Weber, Chairman of the Joint AIEE-IRE Committee on High Frequency Measurements, was toastmaster; this was attended by approximately 175 conference members and guests. After a brief review of this, the Second Conference on High Frequency Measurements, Dr. Weber introduced AIEE President Titus LeClair, who presented a scroll to Dr. E. U. Condon, Director of the National Bureau of Standards, in recognition of the fiftieth anniversary of the Bureau of Standards and its accomplishments.

President LeClair stated: "For 50 years, the National Bureau of Standards has stood as the solid rock on which science and engineering have built an ever larger and ever more complex temple of progress for the country. Each new discovery brings new units which must be defined and measured. The Bureau has kept abreast of each new development in research and testing to measure and define the standards for all new units in new fields of science.

"It is fitting that on this 50th anniversary, we pause to honor this great institution, whose work we often take for granted, and on which so much depends. The electrical engineers, who represent only a part of the great body of those who use the services of the Bureau of Standards, are honored to take part in this joint meeting."

In the scroll, the Bureau was congratulated on its "outstanding accomplishments in establishing and maintaining standards of measurement, quality, performance, and practice which serve the general public and form the basis for all engineering, its valuable contributions to science and engineering through its testing and research facilities, and its splendid achievements in the development of precision measurements and the determination of the magnitudes of the ampere, the ohm, and the volt in absolute units, standards in frequencies."

Then IRE President I. E. Coggeshall

presented his society's scroll to Dr. Condon in similar recognition of the Bureau of Standards' great work.

In accepting the scrolls, Dr. Condon told how the Bureau which he heads has expanded in half a century from its original purpose of establishing standards of all types into new fields of effort, especially those of the military. That its growth is continuing, he said, was evidenced by the fact that by the summer of 1952 the major laboratory for studying the propagation of radio waves and their measurement will be operating at Boulder, Colo. Guided missile work will be performed in southern California in an area taken over from the Navy.

INSPECTION TRIPS

After the luncheon, those attending the conference had the choice of four inspection trips: the National Bureau of Standards, the Naval Observatory, the Naval Ordnance Laboratory, or the Naval Research Laboratory. At NBS, visitors saw the 50,000,000-volt Betatron which is used for basic research and medical and industrial application; the NBS Eastern Automatic Computer, or SEAC, which is the fastest general purpose automatically sequenced electronic computer now in operation; and those laboratories where work is being conducted on primary standards and the development of several types of atomic clocks.

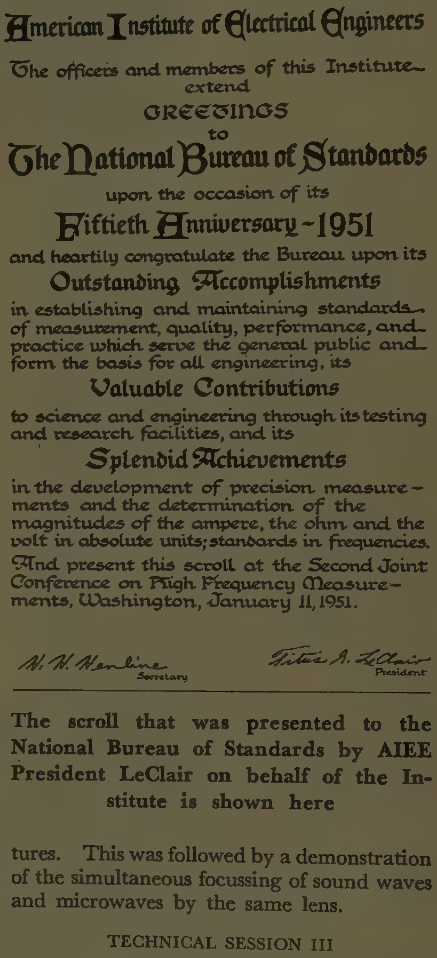
At the Naval Observatory, visitors saw the equipment which controls radio time signals with a precision of a few milliseconds and several types of telescopes. The vacuum-type supersonic wind tunnels attracted the most attention at the Naval Ordnance Laboratory. The oldest of the Navy's laboratories, the Naval Research Laboratory, showed the visitors a recently unclassified moving picture of the operation and take-off of the Navy's Viking Rocket; afterwards the visitors were shown the most recent developments of antenna developments for microwaves' transmission and reception and the instruments and antennas used for measuring extraterrestial radiation, the latest of which is a 50-foot parabolic antenna used for studying radiation from the sun.

DEMONSTRATION LECTURES

Three demonstration lectures on Thursday evening marked the annual joint meeting of the Washington Section of the AIEE and IRE in the Interior Department auditorium. E. I. Green, Chairman of the IRE group, Joint AIEE-IRE Committee on High Frequency Measurements and the Chairman of the AIEE Science and Electronics Division, presided. The first lecture of the evening "Recording Atmospheric Index of Refraction at Microwaves," was presented by George Birnbaum assisted by S. J. Kryder and R. R. Larson, all of the National Bureau of Standards. The recording microwave refractometer, which is an instrument for measuring and recording minute differences in frequency between a test cavity and a reference cavity, was demonstrated. Fluctuation in the refractive index of the atmosphere was demonstrated by means of the output meter of the instrument being projected on a screen, variations being noted when someone breathed into the test cavity or a moist blotter was held near it.

"Microwave Spectroscopy with Applications to Chemistry, Nuclear Physics, and Frequency Standards" was the title of the second lecture presented by L. J. Rueger, R. G. Nuckolls, and Harold Lyons, all of the National Bureau of Standards. A Stark-modulation type of microwave spectrograph was demonstrated by displaying the absorption lines of ammonia gas on a projection oscilloscope and it was explained how this apparatus could be applied to chemical analysis, chemical reaction range, isotope analysis, and nuclear physics.

The last lecture of the evening was given by W. E. Kock, Bell Telephone Laboratories, and entitled "Measurements of Microwave Field Patterns Using Photographic Techniques." Slides of space patterns of microwaves and centimeter wavelength sound waves were shown and these slides were followed by a demonstration of refraction, defraction, and focussing of these very short waves by different metallic structures. This was followed by a demonstration of the simultaneous focussing of sound waves and microwaves by the same lens.



American Institute of Electrical Engineers

The officers and members of this Institute
extend
GREETINGS
to
The National Bureau of Standards
upon the occasion of its
Fiftieth Anniversary ~ 1951
and heartily congratulate the Bureau upon its
Outstanding Accomplishments
in establishing and maintaining standards of measurement, quality, performance, and practice which serve the general public and form the basis for all engineering, its
Valuable Contributions
to science and engineering through its testing and research facilities, and its
Splendid Achievements
in the development of precision measurements and the determination of the magnitudes of the ampere, the ohm and the volt in absolute units; standards in frequencies.
And present this scroll at the Second Joint Conference on High Frequency Measurements, Washington, January 11, 1951.

H. H. Henline
Secretary

Titus G. LeClair
President

The scroll that was presented to the National Bureau of Standards by AIEE President LeClair on behalf of the Institute is shown here

TECHNICAL SESSION III

The third technical session held on Friday morning was devoted to the measurement of power and attenuation and E. W. Houghton, Bell Telephone Laboratories, presided. The first paper "Absolute Microwave Power Measurements" by A. C. MacPherson and D. M. Kerns, National Bureau of Standards, was read by the latter. Work done at NBS concerning bolometers and calorimeters as devices for precise measurement of microwave power were reviewed. Special techniques developed for the determination of bolometer mount efficiency by means of impedance measurements were described and a differential microcalorimeter which was developed and used for power measurement at the milliwatt level also was explained.

The second paper, "Broadband Bolometer Development," was presented by W. E. Waller, Polytechnic Research and Development Company. Broad-band bolometers for high-frequency power measurements were discussed; they cover the ranges 20 to 1,000 megacycles, 1,000 to 4,000 megacycles, and 4,000 to 10,000 megacycles. All these units have a VSWR under 1.3 over their specified operating ranges. Low-power and high-power elements capable of dissipating 1 milliwatt and 100 milliwatts respectively have been made to these specifications. The speaker described the response and power handling capabilities of these elements to short pulses.

H. R. Meahl and C. C. Allen, General Engineering and Consulting Laboratory, General Electric Company, presented "Calibrating Ammeters above 100 Megacycles." A survey was made of the progress up to now in measuring current above 100 megacycles. The types of vacuum thermocouples available for ultrahigh-frequency current measurements were discussed and the several methods of calibration reviewed. A calorimeter method and a thermistor bridge method were presented which were satisfactory from 100 to 1,000 megacycles. It was brought out that the electrodynamic method is particularly suited to large currents, the calorimeter method to medium currents, and the thermistor bridge method to small currents. The importance of obtaining agreement between methods that do not depend on the same principles was emphasized.

"A Microwave Oscillograph" was the title of the next paper by W. B. Sell and J. V. Lebacqz, The Johns Hopkins University School of Engineering, and was read by the latter. A cold-cathode high-voltage single-transient Rogowski oscillograph given to The Johns Hopkins University by the Aberdeen Proving Ground was redesigned to permit the direct observation of frequencies in the 10,000-megacycle range. This has been accomplished in two ways—first, by velocity-modulating the beam by the voltage field of a waveguide, then deflecting it through a constant magnetic field; second, by using a short Lecher wire system for the transmission of the microwave energy. In this latter case deflections due to both the voltage and magnetic fields were observed. A theory was offered which checks the voltage field deflection much more closely than the predictions of Hollmann, who worked on the dynamic sensitivity and calibration of cathode-ray oscilloscopes at very high frequencies.

J. H. Vogelman, Watson Laboratories, presented "Precision Milli-Decibel Waveguide Attenuation Measurements." The precision measurement of the attenuation of 4-terminal low-loss microwave structures is based on the relationship between the attenuation and the resultant standing wave at the input terminal when the structure is terminated in a short circuit. The techniques and necessary precision measurement equipment have been developed to permit accurate measurement of attenuation values between 0.01 and 0.5 decibel, and with decreasing accuracy down to 0.001 decibel. Since the resultant VSWR values are very large, the ultimate accuracy depends on the determination of the relative magnitude of the minimum with respect to the measurabl aximum. Techniques and equipment ere described in which various errors were inimized.

The last paper of the morning session was resented by C. M. Allred, National Bureau Standards, entitled "Dissipative and iston Attenuator Corrections." Termina-on impedances and corrections on rated alues of dissipative-type attenuators termi-ated in any complex impedances were iscussed. Derivation construction and ap-lication of several circle diagrams and omographs were presented and experi-ental verification data were shown for a ide range of frequencies and impedances. lides were shown of nomographs, circle iagrams, theoretical highlights, and some of e latest NBS attenuation standard equip-ent.

TECHNICAL SESSION IV

The final technical session over which E. . Felch, Bell Telephone Laboratories, resided was devoted to the measurement f transmission and reception. The first aper was presented by J. A. Saxton, Radio ivision, National Physical Laboratory, ngland, and entitled "A Field Strength leter for 600 Megacycles." The equip-ent was described which has been designed rimarily for use in the study of radio wave ropagation at 600 megacycles and which as a fairly wide-band intermediate-fre-uency amplifier (0.5 megacycle centered n 30 megacycles) to ensure that a received gnal remains in tune during long periods f recording. As a calibrated instrument, owever, it may be used for the accurate omparison of radio field strengths or powers ver a frequency range from 500 to 700 egacycles.

W. J. Albersheim, Bell Telephone Labora-ries, presented the next paper, "Measuring echniques for Broad-Band Long Distance adio Relays." Adjustment and main-nance of radio relays require sensitive yet pid measurements. By rapid scanning, ansmission characteristics can be traced paper strips or cathode-ray tube screens. ternating switches permit superposition reference traces. Frequency functions us measurable include gain, phase, im-dance, reflection coefficient and their rates change; time functions include amplitude d frequency modulation; amplitude func-ns include frequency-modulation distor-n caused by frequency or noise modula-n, by interference, and by transmission aracteristics.

F. E. Radcliffe, Bell Telephone Labora-ies, presented "Wide Band Swept Fre-ency Measurements Applicable to Travel- Wave Tubes." Methods of measuring nsmission and impedance of traveling-ve tubes operating in the 4,000-megacycle mmon carrier band were described in ich the frequency is swept over a 500-gacycle band. A gain comparator type transmission measuring set was described which moderate oscillator amplitude iations with frequency do not affect the uracy of measurement. By this method nsmission characteristics are measured to uracies of approximately 0.25 decibel return loss can be measured up to values about 40 decibels. A new technique ful in broad-band amplifier measurements s described in which both the trans-sion and output impedance versus fre-ncy characteristics of an amplifier delivering its normal power output to its load are displayed simultaneously on an oscilloscope.

Leonard Swern, Sperry Gyroscope Company, presented the next paper, "Microwave Techniques in the 28,000–300,000 Megacycle Region." Several examples of new millimeter region components were described and their designs evaluated. The author emphasized those techniques fundamentally similar to those effective at lower frequencies. New approaches to the microwave measurements problem were discussed, among them, optical and semioptical approaches and the applicability of molecular resonance absorption.

"Measurement of Characteristics of Crystal Units" was presented by L. F. Koerner, Bell Telephone Laboratories. Recent extensions of the useful frequency range of crystal control into the microwave region by harmonic generation, and the extension of the frequency range of crystal units in filter networks, have called for more accurate measurements of the electrical elements of the equivalent network of the crystal unit. The agreement of frequency measurements of a crystal unit in various test circuits is a function of its Q, and the ratio of its shunt capacitance to the capacitance in the series branch of the equivalent network. If the quality of the crystal unit is maintained sufficiently high, these variations are of the order of a few cycles per megacycle and may be neglected except for precision applications as in frequency standards.

The final paper of the session, "Reflecting Surface to Simulate an Infinite Conducting Plane," was given by S. J. Raff, Naval Ordnance Laboratory. The shape of a flat conducting surface has considerable effect on the microwave reflections from it when the source to reflector distance is of the order of magnitude of the dimensions of the reflector. An optimum shape has been designed for simulating the reflection back to the source of an infinite plane reflector. If the reflection is summed by Fresnel zones, the large effect of the shape of the surface on the reflections can be attributed to the slow rate of decrease of reflections from successive zones. Using the calculus of variations, an optimum shape was designed for a surface inscribed in a circle of 23 wave-lengths diameter, 25 wave lengths from a dipole antenna. The maximum error in simulating an infinite plane reflection was calculated to be 3 per cent. The reflection from this surface has been measured and is within 4 per cent of the infinite plane reflection over the range of 15 to 35 wave lengths from the antenna.

LOCAL COMMITTEE

The members of the Local Committee who manned the desk at the Hotel Statler during the conference were: Mrs. Dolores H. Rhodes, Alf D. Jansson, Michael F. Carbone, Edwin J. Browne, John W. Lowenbach, and Henry Cogan. They handled the registration, inspection tours, luncheons and special events desks very efficiently.

AIEE Philadelphia Section Features Forum at Meeting

At the AIEE Philadelphia Section Meeting on December 11, a forum on "Training an Engineer Industry Wants to Hire" was held. The program was introduced by Section Chairman S. R. Warren, Jr. Dr. Harry Sohon of the Moore School, University of Pennsylvania, acted as moderator and introduced the principal speakers: D. B. Smith, Vice-President in charge of research, Philco Corporation; L. R. Gaty, Manager, Engineering Department, Philadelphia Electric Company; Professor L. V. Bewley, Head, Electrical Engineering Department, Lehigh University; and Charles Weyl, Executive Vice-President, International Resistance Company. These speakers were asked to discuss the question from the points of view of the communication field, the power field, educators, and administrators respectively.

Mr. Smith said that all industries need men who have creative ideas, the ability to get things done, the ability to get along with other people, and technical competence in their field, and that the colleges and universities should consider these needs in planning their curricula. However, the student can expect to learn only the fundamentals while in school; the rest he will have to find out for himself when he starts to practice his profession.

Mr. Gaty thought one of the most important items in training an engineer was to give him a sound foundation of basic engineering fundamentals. The engineer that industry wants to hire should be interested in engineering, have a good grasp of its fundamentals, and be willing to keep on broadening his knowledge and ability. He should be able to work with people, have a good grasp of human relations, and be able to write and speak well. He should know basic economics, he should be honest, and should participate in community and professional organizations.

Professor Bewley differed with the two preceding speakers on the question of fundamentals versus specialization. By the elimination of nonessential and unco-ordinated courses and the substitution of a field of concentration—the much maligned "specialization"—young men are taught to think deeply along a few lines rather than shallowly along many. The five essentials to a strong and virile engineering school are: 1. A teaching staff composed of men who know their subjects and the art of teaching; 2. A modern and strong curriculum patterned after the needs of industry and the profession; 3. A modern laboratory; 4. A carefully selected student body; and 5. An administration with the imagination to see the necessity for these four conditions and the determination to carry them out.

Mr. Weyl listed twelve questions which he considered pertinent, and said that only in some cases had attempts been made to provide for needs suggested by their consideration. Is the graduate engineer interested in engineering? Can he analyze new problems? Can he make, implement, and follow up a decision? Is he dependable and responsible? Can he write clearly and forcefully? Can he organize and systematize himself? Does he know his own strengths and his own weaknesses? Does he know what kind of a person he is himself? Does he know how to get along with his associates? Does he have the qualities of leadership? Is he a stable and mature person for his age? Does he have good judgment in technical matters and in everyday affairs?

In the discussion that followed the talks, questions were raised as to where to draw the line between "specialization" and "fundamentals."

Case Institute Student Branch Meeting. At the regular biweekly meeting of the Student Branch of Case Institute of Technology, Cleveland, Ohio, a lecture on fuses was given by E. R. Kehne of the Busman Fuse Manufacturing Company. He demonstrated the capabilities of the company's Fusetron. The meeting was attended by 60 students, and was held on January 9.

Largest Winter General Meeting in AIEE History Was Highly Successful

The 1951 AIEE Winter General Meeting which was held in New York, N. Y., January 22–26, with headquarters at the Hotel Statler, offered the largest program in the history of the Institute. In 67 technical sessions during the five days, 143 formal papers and 160 Conference Papers were presented. Three general sessions were held at which the Hoover, John Fritz, and Edison Medals were presented as well as the Institute Prizes for papers and the Alfred Noble prize which was awarded to R. J. Kochenburger for an outstanding technical paper by an author under 31 years of age. A total attendance of 3,334 members and guests was recorded.

On the business side of the meeting, over 100 committee and luncheon meetings were held with a Forum of Technical Committee Chairmen on Monday, the meeting of the Sections Committee on Tuesday, and an all-day meeting of the Board of Directors on Thursday.

On the social side, a smoker was held in the ballroom of the Hotel Commodore on Tuesday evening and a dinner-dance in the ballroom of the Hotel Statler on Thursday evening. In addition to the dinner-dance, a special program for the entertainment of the visiting ladies consisting of a tea and get-together, a dinner party and entertainment, a trip to the United Nations at Lake Success, and a luncheon and fashion show at the Plaza were arranged.

Many took advantage of a series of ten inspection trips arranged to nearby industries, utilities, and the United States Signal Corps Engineering Laboratories at Fort Monmouth, N. J., as well as the New York Times, New York Stock Exchange, and the Brooklyn-Battery Tunnel.

TECHNICAL SESSIONS

Technical sessions were held in each of the five broad divisions of Institute activities: communication, industry, general applications, power, and science and electronics. Great interest was manifested in a symposium held Tuesday morning and afternoon which dealt with the operation of power and communication and transportation utilities under military attack. Authoritative speakers described the destructive effects of atomic weapons and protective measures, the effect of bomb blast on power stations during World War II, and the mobilization by communication, transportation, and power companies to meet such emergencies. The presentations and the discussions were entirely informal and off-the-record. No copies of the talks or the papers will be made available.

Another session, "Electronic Paths Under the Sea," commemorated the centennial of the laying of the first armored submarine cable between Dover and Calais in 1851. This epoch of progress in the submarine telegraph cable and submarine telephone cable art was given in three papers. The first told of the genesis of submarine cables. The second and third described submerged repeaters for long submarine telegraph cables and a submarine telephone cable with submerged repeaters which have recently been installed, as well as the latest advances in the art of submarine telegraph and telephone cable lines. The paper, "A Submarine Telephone Cable with Submerged Repeaters" by J. J. Gilbert, is carried in full on pages 248–53 in this issue of *Electrical Engineering*.

From the many sessions, a few of the high spots have been described in the following pages.

COMMITTEES

Members of the Winter General Meeting Committee which made the arrangements are as follows: G. J. Lowell, *Chairman;* C. T. Hatcher, *Vice-Chairman;* J. J. Anderson, *Secretary;* W. J. Barrett, *Budget Coordinator;* C. H. Willis, *Technical Program;* J. D. Tebo, D. W. Taylor, and D. T. Braymer, *General Session;* N. S. Hibshman, *Medals, Operators;* G. T. Minasian and J. B. Harris, Jr., *Publicity;* C. N. Metcalf, *Hotel Accommodations;* E. R. Thomas, *Registration and Checkup;* D. M. Quick, *Smoker;* Mrs. R. F. Brower, *Ladies Entertainment;* E. S. Banghart, *Dinner-Dance;* F. P. Josslon, *Inspection Trips;* J. B. Paszkowski, *Theatre-Radio;* C. S. Purnell, *Vice-President, District 3.*

Unity of the Engineering Profession Discussed at Sections Committee Meeting

The meeting of the Sections Committee was held on January 23 with C. S. Purnell, Chairman in the East, presiding. The principal items discussed were proposed plans for unity of the engineering profession, Institute finances, changes in Section territories, a plan for recognition of Section growth, and general discussion of Section activities. Keen interest was manifested by the representatives from the various Sections as leaders in each of these fields outlined the progress and developments of the topics.

UNITY OF THE ENGINEERING PROFESSION

The progress toward increased unity of the engineering profession and the work of the exploratory group to consider the increased unity of the engineering profession was explained by Past President J. F. Fairman, who is a member of the Planning Committee. He commented on the report of the exploratory group to consider the increased unity of the engineering profession which was adopted in December and which contains four different plans—A, B, C, and D—as a start toward attaining the desired results. The development of the report represented six months' work and it was a tremendous undertaking when it is considered that there were as many as 15 representatives of different societies around the table.

The report had been distributed to the chairmen and secretaries of Sections and Subsections on January 2 with the request that it be studied in company with the members of the Executive Committees or such other groups of interested members with the request that comments and opinions that are fairly representative of the sentiments in the Sections be sent to the Secretary for consideration of the Board of Directors. The Board would not take final action on any plan at this stage of the work, and the report was submitted to the societies represented in the group to obtain comments opinions, and guidance on which the future work of the group might be based.

Further in regard to the matter, Mr Fairman explained that at this stage it was necessary to take a conciliatory attitude and that people should give a little as well as take. Any plan which is adopted must have the backing of a large proportion of the Institute membership and it was suggested that the job of selling the idea must be undertaken in the Institute which has done more groundwork than any of the other societies He urged that the matter should be taken very seriously, and not too rapidly. Members in the Sections should discuss the repor locally with the members of other societies In this way, it was hoped that definite idea on which the Board of Directors could take action might be obtained from the Section by April 1.

(*Editor's Note:* In order to afford every Section and Subsection a more adequate opportunity to consider the report and formulate replies, the Board of Director decided to defer consideration of the repor to their next meeting on April 12 and requested that replies should be received by headquarters not later than April 2 fo analysis and summarization before th Board meeting. Any Section or Subsectio desiring to amend or change its previou reply was invited to do so. A study of th replies so far received suggested a patter for future replies as follows:

1. What plan most closely approach the type of unity organization which desired and would be supported by you members?
2. What are the features of that pla which result in your preference?

3. What are the features which you ould like to have changed to make it more ceptable?

The pattern is not intended to inhibit ny additional discussion, but straight- rward answers to these three questions will e of great assistance in the study. The formation was given in a communication om the Secretary dated February 1 to the nairmen and secretaries of Sections and ubsections of AIEE.)

INSTITUTE FINANCES

The trend in Institute finances leading up the need of an amendment to the Consti- ıtion to transfer the dues requirement from ne Constitution to the Bylaws was reviewed y W. J. Barrett, Chairman of the Finance ommittee. He explained that in the scal year ending April 30, 1947, costs rose narply. The Board of Directors took steps increase the revenue by raising the dvertising rates in *Electrical Engineering*. he rates already were the maximum that ne traffic would bear. Registration fees r attendance at meetings also were put in fect. The annual rate of income, however, id not grow as rapidly as the expenses nd, during the fiscal years ending in 1948 nd 1949, there was a combined deficit of 67,000. The end of the last fiscal year nowed a small deficit of less than $1,000 ut it had been necessary to cut the appro- riation for the number of Technical Papers equested and limit the services rendered in ther ways. It was necessary to watch the ıcome and expenses very closely and it ould be unwise to draw from the reserve r operating expenses, particularly as the eadquarters building was old, small, and bsolete in many ways.

Mr. Barrett explained that under the esent system it would take from $1\frac{1}{2}$ to $/_2$ years to make an increase in dues fective, depending upon when the wheels ere started turning; therefore, he con- lered it very essential that the Constitution ould be amended and the dues require- ent transferred to the Bylaws so that the bard of Directors, in an emergency, could something in less than $1\frac{1}{2}$ to $2\frac{1}{2}$ years d he felt that favorable action would be ken on the matter. In conclusion, Mr. rrett stated that it had been over one- arter of a century since the Institute had d a dues increase. The AIEE also has e largest membership with a small staff hich is only about 40 per cent of The nerican Society of Mechanical Engineers SME) staff.

In discussion of the matter, the following ws were expressed: It was reported that Institute of Radio Engineers had taken dues requirements out of their Constitu- n and put them in the Bylaws. In re- onse to a question in regard to the ASME es, W. B. Morton, representing the Lehigh lley Section, advised that the ASME mbership recently voted a dues increase $5.00 for senior members but the increase not apply to the younger members and ent college graduates. G. W. Bower sed the question that the proposal was taking the matter out of the hands of members and putting it in the hands of Board of Directors. He also inquired to how the expenses were running with current budget. In response, Mr. rrett replied that figures are not available on the current financial position on a fiscal year basis, which is the important consideration. Since the Board of Directors exercises full control over everything a member receives for his dues they could undoubtedly be relied upon to apply equal care and good judgment to the matter of dues.

W. G. Hoyle, Chairman of the Ottawa Section, and F. H. Pumphrey, Chairman of the Florida Section, expressed the belief that an increase in dues would be resented by members in territories who are remotely located from centers of activity where meetings are held and that they would particularly resent it if more money were given to the larger Sections.

On the other hand, L. N. Grier, Chairman of the Pittsburgh Section, expressed the view that the dues requirements should be in the Bylaws although it might be a blow to the younger members, which blow could be softened by having payments in two or three installments. J. J. FitzGibbon, Chairman of the West Virginia Section, believed that an increase in dues was only natural as everything else had gone up in price and he also believed that a payment in two installments for the younger members would be desirable.

In conclusion, C. S. Purnell, Chairman of the Sections in the East, summarized the matter by saying that we were all more or less in favor of the proposal and he urged that the representatives should take back to the Sections the good reasons brought out in the meeting so that when ballots are received members in the Sections will vote intelligently on the matter.

CHANGES IN SECTION TERRITORIES

In view of the reasons explained by H. R. Fritz, Vice-President of the South West District, and in accordance with the established procedure, the Sections Committee recommended to the Board of Directors changes in Section territories as follows:

1. Transfer Kay County, which is closer geographically to Tulsa and with similar interests, from the Oklahoma City Section to the Tulsa Section.
2. Transfer the Lake Charles Subsection of the New Orleans Section from District 4 to District 7.
3. Transfer the Shreveport Section in District 4 to District 7.
4. Establish as a full Section the Albuquerque Subsection of the New Mexico–West Texas Section and its territory of 13 counties presently assigned to the New Mexico–West Texas Section.

(Subsequently, the Board of Directors approved these recommendations—the transfer of Kay County to the Tulsa Section is to become effective immediately; the transference of the Lake Charles Subsection and the Shreveport Section will not become effective until August 1, 1951; the Albuquerque Subsection is to be granted full Section status immediately and will be known as the Northern New Mexico Section.)

PLAN FOR RECOGNITION OF SECTION GROWTH

A plan for the recognition of Section growth drawn up by a specially appointed committee was outlined by C. G. Veinott, Vice-President of District 2. A similar plan had been developed and adopted in District 2 for the years ending August 1, 1949, and August 1, 1950. The purpose was to encourage Sections by recognizing and rewarding outstanding efforts. The special committee was appointed to study the Section growth plan and determine if that plan or a similar plan could be adopted on a national scale. The committee, after considering all of the various factors involved, has developed a plan with a formula based on the growth in membership and growth in attendance which is recommended for application on a national basis. Mr. Veinott explained the various factors taken into consideration to make the plan equitable for varying conditions in the development of the formula. For the purposes of awards, the Sections are divided into two groups, large sections and small sections. First and second prizes will be awarded to the two sections in each group having the highest and second highest growth factors in each group.

The Section Committee endorsed the plan in principle and recommended transmission of it to the Board of Directors with the further recommendation that the results of the awards be given wide recognition and published in *Electrical Engineering*. (Subsequently, the Board of Directors at its meeting of January 23 approved the plan. The special committee will determine the winners for the year ending August 1, 1951; after that, the plan will be administered by a special subcommittee on Section growth of the Sections Committee.)

PUBLIC RELATIONS

The aims and objectives of the Public Relations Committee and the work done by Raymond C. Mayer, who has been retained as Public Relations Counsel, were reviewed by G. T. Minasian, Chairman of the Public Relations Committee. Briefly, the objective is to interpret the work being done in electrical engineering by the engineer and put it across to the public. Originally, activities were mainly confined to the New York meeting but the committee was looking for ways to broaden the service. Mr. Minasian advised that he had been astounded at the quantity and quality of material distributed from Mr. Mayer's office to 250 newspapers and news services which involved over 75,000 releases. He referred to the publicity kits which were distributed to the Sections and stressed the importance of passing them on to incoming chairmen or those who do publicity work. He advised that Mr. Mayer was at the service of the Sections and that the Public Relations Committee would like to obtain a greater response and would like to know where they could be of help.

From the point of view of the larger sections, Mr. Minasian's remarks were supplemented by Dr. J. D. Tebo of the New York Section. He cited that in the large sections it was advantageous to have two publicity chairmen—one to look after the Institute publicity and to prepare meeting notices and announcements which are mailed to the members, and the other to take care of public relations by concentrating on preparing stories for the newspapers and the public. In the larger cities, the news received in the editorial offices of the newspapers greatly obscures the news pertaining to meetings and Doctor Tebo suggested that it would be more advantageous to concentrate on the suburban or hometown papers which are more receptive and often include personal items about the chairmen, the speakers, and so forth.

MEMBERSHIP AND TRANSFERS

The Chairman of the Membership Committee, J. C. Woods, advised that from the figures he had seen it was gratifying to know that the Institute was growing at a faster rate than ever before. In regard to prospective members, Mr. Woods stressed the need of following through on all prospects and he emphasized the importance of taking a more aggressive attitude to see that prospective members are given sufficient information and the application forms in each case.

In regard to the work on transfers, C. W. Frick, Chairman of the committee, explained that one of the duties was to prepare and maintain a manual or operation guide for section transfers. In view of the proposed changes required for admission or transfer to the several grades of membership and the efforts to obtain uniform grades, he explained that it would be unwise to attempt to get out a guide at a $500 or $600 printing expense while these changes are under way.

INCREASING MEETING ATTENDANCE

Various ways in which to increase the attendance at Section Meetings were brought out in discussion. W. R. Way of the Montreal Section reported that scheduling more inspection trips in the programs had increased the attendance, and E. M. Morecock, Chairman of the Rochester Section, expressed the view that diversified programs were one of the best ways to bring people out to meetings. W. G. Hoyle of the Ottawa Section expressed the view that if meetings are held too frequently there is a loss in attendance. In the Lehigh Valley Section where members are widely scattered in different towns, W. B. Morton reported that good results had been obtained by keeping lists of members in the various towns and finding out if they had transportation and then arranging car pools to provide transportation to the meetings. In the New York Section, J. D. Tebo reported that the attendance was not so high last year, but they had had 1,700 who attended a demonstration lecture. Educational meetings and meetings with servomechanisms as the subject did very well. Sometimes if tickets are provided, it has a good psychological effect as people feel more obligated to attend.

STUDENT BRANCH ACTIVITIES

In introducing the subject, Chairman Purnell remarked that it was difficult at this time to judge the possible effects of the increase in Student dues, and he suggested that ways of broadening and expanding the services at the Student level should be explored. H. A. Dambly of the Philadelphia Section reported a very successful Student dinner with a panel of four professors and 125 seniors. Members sat with the Students and paid for the dinner.

In regard to Student guidance work, Dr. J. D. Tebo explained that through ECPD representatives had been sent to the high schools to inform students of the opportunities in the engineering field and the procedure had been well received in the New York area. He suggested that other Sections in areas which have a fairly large number of high school graduates might find it valuable to inform the students about the electrical engineering field and undertake similar student guidance work. The representatives sent to the high schools used information contained in an article, "Professional Opportunities in Electrical Engineering," by C. F. Dalziel, published in the California Journal of Secondary Education, December 1947. The permission of the author and publisher had been obtained to reprint this for distribution to high school graduates.

SECTION MODEL BYLAWS

Attention was drawn by J. D. Tebo to the part of the model Bylaws which suggests that Section officers should progress and he pointed out that as the District Executive Committee consists of only a secretary-treasurer and a chairman, during a 3-year period there was a time when the secretary-treasurer dropped out. He suggested the addition of the office of a vice-chairman. Chairman Purnell, however, pointed out that if the office of vice-chairman were established it would be an additional expense item. He suggested the appointment of a committee to make a careful study of the matter and report back to the Sections Committee.

General Sessions Feature Hoover, Edison, and John Fritz Medal Presentations

Three general sessions were held at the 1951 Winter General Meeting in order to present the Edison, Hoover, and John Fritz Medals to their respective recipients, and to award the Institute and Student Paper Prizes to the winners.

The first session, held the afternoon of January 22, opened with an address by AIEE President LeClair entitled "Continuing Technical Leadership" in which he showed that the number of engineering graduates is dropping each year and by 1954 there will be only 15,000 graduates (for full text of address, see *EE, Feb '51, pp 95–6*).

James J. Orr, Chairman of the Committee on Award of Institute Prizes, introduced the recipients of the awards for the Student and Institute Paper Prizes; the winners who attended the meeting came up to the platform to receive their prizes and were then congratulated by Mr. Orr and President T. G. LeClair.

TECHNICAL AND STUDENT PAPER AWARDS

The Best Student Prize Paper was awarded to Charles F. Strandberg of Duke University, and the Second Prize Student Paper award was made to Samuel A. Schwartz of the University of Alabama.

The Institute prizes, awarded on a division basis, were as follows: Communication Division, first prize to John Meszar, second prize to B. Ostendorf, Jr.; General Applications Division, first prize to C. P. Hayes and H. R. Gould, second prize to Professor C. F. Dalziel and T. H. Mansfield; Industry Division, first prize to Ralph J. Kochenburger (who was also the winner of the Alfred Noble Prize award), second prize to J. E. Ryan; Power Division, first prize to E. E. George, H. W. Page, and J. B. Ward, second prize to F. E. Andrews, L. R. Janes, and M. A. Andersson; Science and Electronics Division, first prize to H. A. Romanowitz and W. G. Dow, second prize to T. R. Specht and R. N. Wagner. A

Ralph J. Kochenburger is shown receiving the Alfred Noble Prize award from Ernest D. Howard, Past President of the American Society of Civil Engineers. This award is made annually by the four founder societies and the Western Society of Engineers to any of their members of any grade for a technical paper of particular merit accepted for publication by one of the societies, and the recipient must be under 31 years of age

more complete account of these awards will be found in the February issue of this magazine, pages 165–6.

HOOVER MEDAL PRESENTATION

The 1950 Hoover Medal was presented to Dr. Karl T. Compton. Dr. Scott Turner, Chairman of the Hoover Medal Board of Award, presided over this part of the program and presented the medal to Doctor Compton. Dr. C. G. Suits gave a career citation on Doctor Compton who, in turn, gave an address on "Engineers and National Security." He said that the most serious bottleneck to American accomplishment is lack of the proper quality of man power in positions relating to national security, and that we should make a conscious effort to find promising young men and try them out in jobs of increasing responsibility as they show possibility of discharging it. Doctor Compton's and Doctor Suits' addresses appear in full on pages 190–96 of this issue of *Electrical Engineering*.

After Doctor Compton's speech, it was announced that four guests were present at the meeting honoring their brother: Mr. and Mrs. Arthur H. Compton and Mr. and Mrs. Rice of Pakistan.

ALFRED NOBLE PRIZE AWARD

The Alfred Noble Prize was presented to Ralph J. Kochenburger, assistant professor of electrical engineering at the University of Connecticut, by Ernest D. Howard, immediate Past President of the American Society of Civil Engineers. Mr. Howard gave a brief biography of Alfred Noble and a history of the prize.

JOHN FRITZ MEDAL PRESENTATION

A general session was held on January 23 for the purpose of presenting the John Fritz Medal to Vannevar Bush. James F. Fairman, Chairman of the John Fritz Medal Board of Award, presided at this session and presented the medal to Doctor Bush. The accomplishments and career of the medalist were given in an address by AIEE Past President Everett S. Lee. In the absence of Doctor Bush, who was ill at his home in Washington, President LeClair read his response. Doctor Bush stated that in this new time of peril the nation needs a large reservoir of trained military man power which can only be brought into being by universal military service; in addition, we need greater fire power to offset the numerical superiority which we may face. Although the need of the armed forces for engineers is great, if they are called up in too great numbers, we are in some danger of wrecking the industry we are trying to put back on a war production basis. Doctor Bush's address appears in full on pages 197–201 in the current issue of *Electrical Engineering*.

EDISON MEDAL PRESENTATION

At the general session held on January 24, the Edison Medal was presented to Otto B. Blackwell by President LeClair. J. B. MacNeill, Chairman of the Edison Medal Committee, gave the origin of the medal, and Dr. Harold S. Osborne told of the career and accomplishments of the medalist. In his response, Mr. Blackwell said that the most important problem today was the one of human relations and that he wondered what a large-scale scientific investigation, approaching this problem, could do for it. Man is advanced intellectually but not emotionally, and he should employ every tool and technique at his command to work on the problem of emotional childishness. The complete addresses may be read in this issue on pages 185–89.

Dr. Karl T. Compton, Chairman of the Corporation of Massachusetts Institute of Technology, is shown receiving congratulations after he was presented with the Hoover Medal during the Winter General Meeting. Left to right are Dr. C. G. Suits, who gave the career citation of the medalist; AIEE President LeClair; Doctor Compton; and Dr. Scott Turner, Chairman of the Hoover Medal Board of Award

Forum of Technical Committee Chairmen Held During Winter General Meeting

The second Forum of Technical Committee Chairmen to provide for an exchange of views under the expanded technical committee structure was held on Monday evening, January 22, with the Chairman of the Standards Committee, E. B. Paxton, presiding.

The principal topics discussed at the forum concerned the personnel organization of technical committees, the increasing proportion of Conference Papers and divisional publications, Institute prize award practices, and the waiving of nonmember author registration fees. President T. G. LeClair, Honorary Chairman, opened the meeting with a statement of the objectives of the forum-type of session. He believed that in the future once a year would be often enough to hold this type of meeting.

PERSONNEL ORGANIZATION OF TECHNICAL COMMITTEES

The procedure for the personnel organization of technical committees which provides for wide geographical distribution and a 25-per cent turnover of committee members with provision for continuity of the work was explained by M. J. Steinberg, Chairman of the Technical Advisory Committee. He stated that the Secretary, R. S. Gardner, had prepared a brief write-up of the procedure which was sent to all appointed committee chairmen. Incoming chairmen had been asked to screen lists of recommended personnel and these chairmen are given very wide latitude when making recommendations.

In conclusion, he explained that pamphlets or manuals were available on the preparation of papers, policy, and procedure for AIEE Special Technical Conferences, Standards, and Technical Program Committee work. Names should be left with R. S. Gardner if a copy is desired. Technical Committee Chairmen should not hesitate to take up any problems with their Divisional Committees or with the AIEE headquarters staff.

INCREASING PROPORTION OF CONFERENCE PAPERS

The increase in the number of Conference Papers and the decline of regular papers in proportion to the growth of membership was reviewed by Dr. K. B. McEachron, Chairman of the Publication Committee. When the conferences were originally established, they were intended to be informal without reporting and without publication. With time, the Conference Papers have in many ways become prepared papers. The history over a 20-year period is indicated as follows:

	Calendar Years				
	1930	1935	1940	1944	1950
Number of Conference Papers		64*	58*	88*	284
Number of District Papers		8	12	21	105
Number of ACO Papers	32	3	8	8	44
Total of unpublished papers	32	75	78	117	433
Number of Transactions Papers	167	127	155	231	238
Membership as of May 1st	18,003	14,269	17,213	21,407	34,198
Unpublished Papers×100/Membership	0.178	0.526	0.453	0.546	1.27
Published Papers×100/Membership	0.93	0.89	0.90	1.08	0.696

* 50 per cent estimated (assumption 4 papers per conference).

Concern was expressed over this way of growth, particularly in respect to its effects on the formal types of papers. Doctor McEachron recognized that certain Conference Papers contain valuable material but there were other types of papers which should be Advance-Copy-Only (ACO) material. The practice which permits some authors who have good facilities for the reproduction of their papers to distribute them at the meetings was unfair to other authors who have good material but lack the facilities for reproduction and distribution. He explained that there was some feeling that the Institute should provide copies of the Conference Papers in some way. He further advised that one large group felt that all of their papers should be of the conference type. This procedure does not seem to be a good solution as the great majority of members cannot attend meetings.

The entire matter has been of concern to the Publication Committee for some time and a thorough study is being made but that study is not yet complete. It is not entirely a Publication Committee responsibility.

DIVISIONAL PUBLICATIONS

In regard to the proposal to issue divisional publications every three or four months in the five divisions—communication, general applications, industry, power, and science and electronics—Doctor McEachron explained that the Publication Committee has made a preliminary study of the matter. An analysis of over 6 per cent of the orders received for 1949 papers indicates that most people are ordering Proceedings papers in the fields of three or more divisions. A separate study made by a specially appointed committee, F. R. Benedict, Chairman, in which 330 members were questioned, came up with somewhat the same answer indicating that approximately 65 per cent of those questioned were against incorporating sectional material in packages. In conclusion, Doctor McEachron stated that the Publication Committee does not know enough about the problem. For example, it is not known how many people are in each of the five divisions. When Year Book cards are sent out to the membership, it may be possible to obtain this information. The action taken by the Publication Committee today was to defer the matter until more information can be obtained.

AIEE PRIZE AWARD PRACTICES

The Chairman of the Committee on Award of Institute Prizes, J. J. Orr, advised that consideration had been given by his committee to a better procedure for the selection of prize papers. He explained that there was considerable opposition to the prize awards rules as now in effect and almost unanimous opinion had been expressed that the award of cash prizes constituted putting a price tag on the preparation of papers. The committee had recommended the abolishment entirely of division prizes and their cash awards. In place of these prizes, the committee recommended the reinstatement of recognition for the best initial papers. There was some difference of opinion as to whether the award for the best initial papers should be in the nature of a cash award.

In respect to Student Paper Prize awards, the committee favored the continuation of the present system. It also was voted that the committee should request clarification of ambiguity in the paragraph of the "New Prize Rules for Technical Papers" in regard to the submission of papers to the District and Institute secretaries.

In conclusion, Mr. Orr explained that the committee took action which instructed the chairmen to appoint a subcommittee whose duty it shall be to draw up a resolution on the revision of the prize rules and to present it to the Committee on Planning and Co-ordination for consideration. The subcommittee has not yet been appointed and the matter was put on the agenda of the forum with the hope that suggestions might be received which would be helpful in determining the future procedure for amending the prize awards procedure. There was no discussion of the matter.

AUTHOR REGISTRATION FEES

Various views were expressed on the embarrassment which results when invited nonmember authors and member authors are required to pay a registration fee. The Chairman of the Committee on Basic Sciences, Professor M. G. Malti, advised that his group had five subcommittees and that most of the members were not members of the Institute. Some nonmember authors were prominent mathematicians and physicists, members of the American Physical Society, and it was embarrassing to him as well as the chairmen of the subcommittees to require them to pay a registration fee. Similar views were expressed by several other technical committee chairmen and a discussion arose as to whether invited nonmembers should be given courtesy admission to the sessions in which they are involved or for the entire day or the duration of the meeting. The Chairman of the Committee on Safety, Dr. W. B. Kouwenhoven, explained that at American Medical Association meetings nonmembers were invited to attend all sessions for the duration of the meetings. The Chairman of the Technical Advisory Committee, M. J. Steinberg, sug
gested that nonmember authors be classifie
in two different categories: those who a
looking for the advantages of the meetin
should pay registration fees; and whe
prominent scientists are invited for th
benefit of Institute membership, they shoul
be given free admission to the session
The question was raised by Elgin B. Robert
son as to whether those proposing to waiv
the author registration fees would be willin
to have the equivalent loss of income adde
to their dues. Another view was expresse
that to waive only the nonmember autho
fee and not waive the member author fe
would be an incentive for the production
more nonmember papers.

To crystallize the various views on th
matter, a poll with several alternatives wa
taken. The forum voted unanimously t
waive the registration fees for all non
member authors. It was also voted to waiv
the fees for the duration of the meetings. I
respect to waiving the registration fees fo
invited member authors and all membe
authors, the forum went on record as bein
opposed to this proposal. The Chairman o
the Committee on Planning and Co-ordina
tion, M. D. Hooven, agreed to draw up
brief presentation of the matter for pres
entation to the Board of Directors.

CONFERENCE PAPERS

The discussion on waiving the nonmembe
registration fees for authors reverted bac
to the discussion of Conference Papers
Dr. C. F. Wagner expressed the view tha
the waiving of nonmember registration fee
would not have arisen if there had not bee
so many Conference Papers and he suggeste
that something should be done to reduc
their number. On the other hand, in th
field of basic sciences, the view was expresse
that it was necessary to get material as soo
as available and the only way this could b
done was to have it in the form of Conferenc
Papers. Objections to the presentation o
Conference Papers were raised by Docto
McEachron on the basis that members wh
need the information cannot get it and th
record of the discussion is lost. It also wa
an easy way to get a paper presented quickl
without going through the channels of ap
proval. Furthermore, a month or so afte
the presentation, authors are not willin
to furnish illustrations and the necessar
material to enable their papers to be pub
lished. Also, such papers can be far mor
commercial than the regular papers becaus
they are not reviewed. The Publicatio
Committee had recommended to the Tech
nical Program Committee that the program
should be so arranged that the Transaction
and ACO papers would be presented firs
followed by an intermission and the pres
entations of the Conference Papers, but
was understood that there were objections t
the recommended procedure on the basis
discrimination. The view was expresse
by S. B. Crary that the Conference Pape
were a good thing but what seemed to b
needed was a uniform way of handling the
and he suggested that if they were budgete
some of the difficulty would be overcome.

The suggestion was made by G. W
Heumann that the Institute should accu
mulate an archive of the current Conferenc
Papers at headquarters so that a phot
graphic record could be made for peop
interested in obtaining copies. The discu

ion was summarized by E. I. Green of the Technical Advisory Committee to the effect hat it was the sense of the forum that Conference Papers are a desirable part of the programs and that there should be a conerted plan for looking at the Conference Papers and then getting them published n *Electrical Engineering* and the *Transactions.* The matter was tabled to be put on the genda of the next forum meeting to be held during the Summer General Meeting n Toronto.

Eta Kappa Nu Presents Award to Outstanding Electrical Engineer

Donald P. Campbell, Professor at Massachusetts Institute of Technology (MIT) and well-known authority on servomechanisms, was the recipient of Eta Kappa Nu Association's Recognition Award for being the Outstanding Young Electrical Engineer of 1950, at their annual dinner on Monday, January 22, during the AIEE Winter General Meeting. Honorable Mention Certificates were presented to R. W. Mayer of Westinghouse Electric Corporation, and A. W. Edwards and K. A. Kesselring, both of General Electric Company.

One of the most highly honored citations in the engineering profession, the award, the 15th to be presented so far, is given to a man less than 35 years old and not more than 10 years out of college who has demonstrated by his achievements in technical, civic, educational, artistic, or in other fields, outstanding ability and great promise for the future. The award recipient is selected by a Jury of Award Panel which this year included the following distinguished members of the electrical profession: Fischer Black, Editor of *Electrical World;* Robin Beach, Robin Beach Associates; Dean Erich Hausmann, Polytechnic Institute of Brooklyn; A. H. Kehoe, Vice-President of Consolidated Edison Company; and Frank E. Sanford, National President of Eta Kappa Nu.

Acting as toastmaster for the occasion, Mr. Sanford introduced A. B. Zerby, national executive secretary of the association, who briefly outlined the history of the recognition award. Mr. Black, Chairman of the Award Committee, introduced the honorable mention winners and cited their achievements.

Prof. H. L. Hazen, Head of the Electrical Engineering Department at MIT, introuced the Award winner, giving his backround and citing the achievements which arned him this recognition. The citation read: “By virtue of his notable contributions to servomechanism theories and their inustrial applications, his exceptional teaching abilities, and his outdoor activities for the benefit of others.” Mr. Campbell acepted the award and gave an interesting talk on the importance of western Europe in our defense program. Based on facts athered on a recent tour of that territory, his talk covered many recent European technical advances, and showed the importance of this region in engineering skills nd industrial productivity to our common ffort against communism.

Dean O. W. Eshbach, Northwestern Technological Institute, then introduced Dr. Frederick E. Terman, Dean of Stanford University, and Dr. Joseph Slepian, Westinghouse Electric Corporation, newly inducted eminent members of Eta Kappa Nu. Dr. Terman, principal speaker of the evening, chose as his topic “The Outlook for Electrical Engineering Education.” He pointed out that a serious shortage of engineers was imminent and that the problems confronting engineering educators are becoming increasingly grave. He expected that graduate work in the future would be almost a requirement for engineers to practice their profession. The rapidly expanding field of electronics will necessitate greater application of basic principles, and the main problem confronting educators will be concentrating the engineering curriculum on these fundamentals.

Session on Field Testing of Insulation and Oil Tests

A session covering field testing of insulation as well as the testing and rehabilitation of insulating oil was held the morning of January 22 with F. C. Doble, Doble Engineering Company, presiding. The first paper presented at this session was “Current Practices in Electrical Tests on Dielectrics in the Field,” a preliminary report by a subcommittee of the AIEE Instruments and Measurements Committee. The paper, read by Mr. Doble, gave the results of a questionnaire which was submitted to 183 utilities and service companies in the United States and Canada to determine the number and types of d-c and a-c insulation tests that were made in the field. The a-c dielectric loss and power factor test, using equipment operating at 215 volts to 10 kv, 60 cycles, is the most widely accepted method, and d-c insulation resistance tests are used by most power systems in evaluating cable and rotating machinery insulation.

The paper “Insulation Field Test Results” was given by W. F. Dunkle of Pennsylvania Power and Light Company. Here Mr. Dunkle showed the need for a well-planned program for field testing insulation. The program must be carried out in a minimum time by a minimum number of men who have been especially trained for the job. Equipment used for the program in the Pennsylvania Power and Light Company included electronic d-c low-voltage (0 to 1,000 volts) equipment, high-voltage (500 to 10,000 volts) d-c equipment, and low- and high-voltage a-c equipment. The low-voltage a-c test set is used to observe power and power factor in insulation rated less than 2,000 volts primary.

“Power Factor Testing of Electrical Equipment to Determine Insulation Values” by J. A. Rawls, Virginia Electric and Power Company, described the history, equipment, and results of a long-range testing program. The tests are used to detect all insulation defects, but they will not detect overstressing of insulation. In this program over 1,200 tests are made each year at a cost of less than $10 per test. Mr. Rawls maintained that the dielectric loss and power factor tests are some of the most valuable tests that can be applied.

The final paper of the session was “A New Concept of Insulating Oil Characteristics” by F. C. Doble, Doble Engineering Company. As it is expected that government control will soon be placed on oil, it is imperative that users of transformers learn to rehabilitate old oil. This can be done at a fraction of the cost of new oil. With good oil the addition of inhibitors will multiply the life of the oil many times. Mr. Doble demonstrated a method for testing oil by measuring intersurface tension between oil and water. For good oil the tension is about 40 dynes per centimeter, but for worn, dirty oil it is about 14 dynes per centimeter.

Six Papers Presented at Session on New Types of Power Rectifiers

Two new types of power rectifiers were covered in the session presided over by W. N. Farquhar, Aluminum Company of America, held on January 22. The first paper, “The Mechanical Rectifier,” was presented by Otto Jensen, I-T-E Circuit Breaker Company. He gave the historical developmental background of the mechanical rectifier, which originated in Germany, and then described the functioning of the equipment and some of the installations. Most of those now in operation have a rating between 5,000 and 10,000 amperes, 100 to 300 volts, 60 cycles. E. J. Diebold of the same company in his paper, “Commutating Reactor Control for Mechanical Rectifiers,” explained that portion of the apparatus in greater detail than the previous speaker.

The next group of papers covered the pumpless ignitron. C. C. Herskind and E. J. Remscheid, General Electric Company (GE), introduced the subject in their paper, “Development of the Pumpless Ignitron,” which was presented by Mr. Herskind. After describing the requirements of this type of rectifier, the speaker discussed the manufacturing problems involved in effecting a good vacuum and the different types of tests employed.

E. W. Hutton read a paper by J. G. Neuland of GE, “Studies of Degassing Processes by Mass Spectrometer,” in which it was explained how this spectrometer was employed in degassing studies concerning the pumpless ignitron; how it is used to analyze the gas and so determine if the chamber itself and the walls of ignitrons are degassed. The final conference paper of the session, “Application of Pumpless Ignitrons,” by Ralph Siegel, also of the GE Company, dealt with the experiences gained by data from the various types of installations of the device. He discussed the economics of these rectifiers both from a maintenance and space-saving point of view.

The technical paper of the session was presented by title only, “Sealed Ignitron Rectifiers for Urban Transit Power Supply,” by D. W. Borst, General Electric Company’

Two Papers Presented at First Full Session on Management

The first full session on management was held on Tuesday, January 23, with C. J. Beller, Cleveland Electric Illuminating Company, presiding. L. E. Simon, Brigadier General, United States Army, presented the first paper entitled, “An Outline of Army Ordnance Research and Development.

General Simon explained where the Ordnance Research and Development Board appeared in the government echelon and gave a few brief descriptions of some of the many research activities the Board is engaged in. He illustrated these descriptions with slides, among which were: pictures of the White Sands Proving Ground in Arizona where the government is carrying on extensive research in the field of guided missiles; interior shots of laboratories where research in the field of surface finishes is being carried on; and pictures of experiments carried on in a supersonic wind tunnel.

The second paper, entitled "Management Development," was presented by William Maloney, Esso Standard Oil Company. The emphasis of his paper was on the fact that management must find men and prepare them for the positions of top responsibility. This requires a deliberate long-range program and Mr. Maloney presented the management development of his own company as an example of such a plan. He illustrated his paper with colored slides showing the various ways in which men are groomed for top management positions. Mr. Maloney pointed out the various conflicts within industry today that management must reconcile, and the many responsibilities which they must accept. It is up to industry to see that the caliber of executives is kept high in order to provide leadership for industry, the government, and the country.

Electronic Instruments Session Devoted to New Developments

The session devoted to new developments in the electronic-instrument field was held January 23 with Rudolph Feldt, Allen B. Du Mont Laboratories, Inc., as chairman. The first of the five conference papers presented at the session was by S. H. Silver, Naval Ordnance Laboratory, entitled "The NOL Self-Contained Multi-Channel Cathode Ray Recorder," in which the apparatus and its functioning was described.

The second paper, "Dynamic Strain Analysis" by C. M. Hathaway and K. C. Rock, Hathaway Instrument Company, contained a description of a resistance strain bridge and a carrier-type strain gauge accurate from 0 to 1,500 cycles, using an input of 5 kc as carrier. A 12-element recording electromagnetic oscillograph is used in conjunction with this latter gauge providing a 6-channel photographic record.

H. J. Nearhoof, Pennsylvania State College, presented a paper written in conjunction with A. H. Benner, also of the College, on "Polarimeter for the Study of Low-Frequency Echoes." This is an electronic installation for analysis of down-coming radio echoes from the ionosphere, 85 to 90 kilometers above the earth, using a frequency of 150 kc.

"New Oscillograph Recording Cameras" was given by H. P. Mansberg, Allen B. Du Mont Laboratories, Inc. One type of camera described enables the operator to view simultaneously the cathode-ray tube screen and a data card by means of a beam-splitter (dichroic) mirror. Another type employs a Polaroid camera so that oscillograms can be finished within two minutes after the traces have been photographed. A continuous recording camera was described providing a film speed up to 200 inches per second.

The final conference paper of the session, presented by H. M. Joseph, National Bureau of Standards, was "Electronic Counting of Worn-Out Paper Money." This is done by cutting a package of 100 bills lengthwise, fanning out the end, and counting them photoelectrically.

Four Conference Papers Presented on Magnetic Materials Session

Four conference papers covering topics in the field of magnetic materials at high frequencies were presented Tuesday morning, January 23, in a session presided over by R. M. Bozorth, Bell Telephone Laboratories, Inc. The first paper in this group, "Electronic and Nuclear Magnetic Resonance," by K. K. Darrow, Bell Telephone Laboratories, Inc., described the general field of magnetic resonance in solids, liquids, and gases. This theory was published first in January 1946. In his paper Doctor Darrow developed the theory to show that magnetic resonance of a proton occurs at $2\mu_P H/h$, where μ_P is the magnetic moment of the proton, H is the field intensity, and h is Planck's constant. For electrons in a paramagnetic substance resonance occurs at $2\mu_e H/h$ (where μ_e is the magnetic moment of the electron), and for electrons in ferromagnetic substances resonance happens at $\nu=2\mu_e\sqrt{BH}/h$, where B is the flux density. This theory is applicable to find the magnetic resonance of other substances, to measure field strength, for stabilizing frequency, for the measurement of the distance from proton to proton, and for the determination of relaxation times.

In the paper "Structure and Properties of Ferrites," F. G. Brockman of Philips Laboratories reviewed the crystal structure of ferrites using a 3-dimensional model of the crystal. Then Mr. Brockman discussed the Néel Theory of paramagnetic and ferromagnetic regions, the consequences of this theory, experimental proof of the theory, and superexchange. In the discourse ferrites were defined as chemical compounds of the general formula MFe_2O_4 where M is nickel, manganese, iron with valances of $+2$ or $+3$, copper, zinc, or cadmium.

The paper "Measurement Technique for Magnetic Materials in the Frequency Range 10^6 to 2.5×10^{10} Cycles per Second" was presented by W. B. Wesphal of the Massachusetts Institute of Technology. In making these measurements and calculating parameters the dielectric constant as well as magnetic permeability had to be taken into account. Wave guides are used for measurements of very high frequencies, and coaxial lines are used for measurements at lower frequencies. In the latter case the sample material is installed in the line.

"Production and Properties of Magnetic Materials Used at High Frequencies" was given by E. Albers-Schoenberg of the General Ceramics and Steatite Corporation. The production of these high-frequency magnetic materials was started in 1949. These ferrites have been blamed for high temperature variation but the effective permeability is actually equal to $\mu_{(\text{true})}/(1+\mu_{(\text{true})}a/l)$, where a is the length of the air gap and l is the effective magnetic path.

Winter General Meeting Has a Session on Industrial Control

One session on control in industry was held Tuesday afternoon, January 23; G. W. Heumann, General Electric Company (GE), was chairman of the session.

The first paper on the subject of control was "Transient Response of Saturable Reactors with Resistance Load" by H. F. Storm of GE. In his paper Doctor Storm analyzed the response of the reactors with respect to changes of control voltage, supply voltage, and load resistance. He proved that the time constant of this type of reactor was proportional to the load resistance and inversely proportional to the control circuit resistance and the line frequency, and that the time constant of the parallel-connected reactor is twice that of the series-connected one.

The paper "Electronically Controlled Half-Wave Excitation for D-C Shunt Motors" by W. S. Kupfer, Jr., and E. E. Moyer, both of Rensselaer Polytechnic Institute, was given by Mr. Kupfer. The paper described a setup constructed at the school and featured performance data of the equipment. Advantages of this equipment are simplicity of construction, a wide stepless range of speed control, and limitation of armature current over the speed range. Disadvantages include the following: a larger motor is required because of the heat generated and the torque is pulsating.

The third paper of this session was given by T. M. Spitler of GE; the title of the paper was "A Short-Cut Method for Determining the Coil Temperature Rise of Solenoids on Duty Cycle." Using conventional methods for determining the duty cycle of solenoids, the hours of testing needed to take into account reasonable values of load, stroke, portion of time energized, voltage, frequency of operation, type of load, and allowable temperature rise would make a complete test prohibitive. In this paper a formula was presented for calculating allowable duty cycle for given temperature rises of solenoids after four short tests have been made; the needed tests are d-c and a-c heat runs, volt-ampere watt data, and rms current measurement during operation.

The final paper of the session, "Hermetically Sealed Components for Industria Control," was given by E. B. Steinberg o Remington Rand, Inc. The sealed component consists of four parts: the termina seal, envelope, component, and fillin medium. Sealing components protects them against atmospheric and environmenta conditions, human tampering, and give longer life; however, the initial cost i higher, equipment weighs more, heat i harder to dissipate, and field servicing i limited.

Therapeutics Session Devoted to Phases of X-Ray Work

Five conference papers were presented a the afternoon session, January 23, devote to different phases of X-ray work; th chairman was H. D. Moreland, Westinghous Electric Corporation. The first paper, rea by T. H. Rogers, Machlett Laboratorie Inc., was titled "The Bases for Establishme of Maximum Energy Ratings for X-Ra

Tubes.” After discussing the factors which nfluence the heat dissipation in an X-ray tube for various periods of time, the author presented a scheme whereby the basic characteristics of a tube may be used to compute its comprehensive rating chart, thus providing data as to maximum energy loading allowable for any period of time.

The next paper, “High Speed Exposure Timing in the Application of X-Rays,” was read by R. L. Wright, Westinghouse Electric Corporation. After describing some of the earlier timers, the author explained a multi-tube electronic timer employing thyratrons and ignitrons as well as amplifiers which can be used for electrocardiographs, cineradiography, and phototiming.

J. E. Jacobs, General Electric X-Ray Corporation, read “The Electrical Conductivity of Cadmium Sulphide When Exposed to Pulsating X-Radiation.” The cadmium sulphide crystal is a variable impedance device, which has a certain time response with radiation. It shows great promise as a detector.

“The Intensification of X-Ray Fluorescent Images” was given by W. S. Lusby, Westinghouse Electric Corporation. The device which makes it possible to obtain a brighter X-ray image is the Fluoricon. In one end of an evacuated glass tube is a fluorescent screen on which X rays impinge after passing through a body. The resulting light ejects electrons from a cesium-antimony photosurface and they move towards a 1-inch zinc-cadmium sulphide screen, the anode, and are focussed there by means of an electrostatic lens system. As this screen is one-fifth the diameter of the fluorescent screen, the image is brighter as more light per unit area is on the anode than is on the first screen.

The final paper of the session was written by W. W. Lang, Eureka X-Ray Tube Corporation; it was “A Rotating Anode Tube for Medium Powered Self-Rectified X-Ray Equipment.” The principles of the rotating anode X-ray tube were reviewed; in this instance the tube was designed for equipment requiring a 100-milliampere tube current with voltages of 85- to 100-kv peak. A description of the tube’s functioning was given together with its construction.

New Techniques of Network Synthesis Described

Some of the new techniques in network ynthesis were described in a session Wednesday morning, January 24. H. J. Carlin of the Polytechnic Institute of Brooklyn presided over the meeting. R. M. Fano, Massachusetts Institute of Technology, presented the paper “The Application of Special Functions to Network Synthesis.” In this paper emphasis was placed on the transmission coefficient of a function. If the real and imaginary parts of a complex variable are known, the curves of the function can be compared to the plot of an electrostatic field. This analogy between field theory and functions of a complex variable can be used for solving problems of network ynthesis.

“Network Synthesis Without Mutual Reactance” was written and presented by R. J. Duffin of the Carnegie Institute of Technology. This described the designing of a network that will give a desired function. A simple transformer bridge circuit was given and the problem was to synthesize the network without using transformers so it would have the same impedance at all frequencies. The method described develops a network which divides into two branches.

The next paper of the session, “Synthesis of R-C Networks with Prescribed Transfer Function,” was given by A. D. Fialkow, Polytechnic Institute of Brooklyn. To develop a 4-terminal passive network with characteristics of a transfer function, a set of necessary and sufficient conditions must be found. In determining the network the positions and numbers of zeros and poles must be found, and the multiplicative constant and the values it may assume should be known. Properties of the function include the following: the transfer function is a rational function; the number of poles cannot be less than the number of zeros; the number of negative poles must be real.

The final paper of this group was presented by R. B. Blackman of Bell Telephone Laboratories, Inc. Its title was “Transducer Design Based on Statistical Properties of the Signal.” The object of the paper was to present a criterion for an optimum system for observing a signal in the presence of noise when both signal and noise are described in certain prescribed statistical ways.

Three Conference Papers Consider Electronic Education

Three conference papers were presented at the session on January 24 when the role of electronic education was discussed. The chairman of this session was J. T. Thwaites, Westinghouse Electric Corporation.

“Electronic Education Requirements for Industry” was the subject of the opening paper, presented by Walther Richter, Allis-Chalmers Manufacturing Company. Mr. Richter stressed the fact that engineering schools should provide the engineering student with certain fundamentals. After his graduation, the company with whom he becomes associated should fill in the details. Mr. Richter pointed out that big companies can afford further education for their employees, but a small company expects a new man to begin producing immediately.

The second paper, entitled “Electronic Education Requirements for the Research Laboratory,” was presented by W. G. Shepherd of the University of Minnesota. Doctor Shepherd stated that scientific personnel in electronic laboratories should have graduate work; research requires special training for which there is no time at an undergraduate level. He also stressed the fact that a student should receive strong training in fundamentals which can be applied later in experiments.

“Electronics in Electrical Education” was the title of the paper presented by J. D. Ryder of the University of Illinois. Doctor Ryder stated that there have been no additions to basic fundamentals since 1900; therefore, changes in teaching are due to other factors. He illustrated the nature of these changes by a series of slides which showed that there has been some increase in the number of non-engineering courses, but the major change in electrical engineering courses has occurred with the introduction of courses in electronics.

Session is Held on Electrical Applications in Hazardous Areas

The session devoted to the reduction of danger and trouble from lightning and other electric phenomena was held Wednesday morning. Kennard Pinder, E. I. du Pont de Nemours and Company, presided over the meeting.

The first conference paper, “Tests of Electrostatic Controls for Hazardous Industrial Applications,” was presented by Robin Beach, Robin Beach Engineers Associated. Different types of static neutralizers were explained as well as the method whereby they were tested and their resulting evaluations. Criteria were given for the selection and use of neutralizers.

“Lightning Protection for Hazardous Buildings and Structures” by J. Z. Linsenmeyer and A. M. Opsahl, Westinghouse Electric Corporation, and read by the latter, described the means by which buildings used for storing explosives or those in which volatile gases may leak are protected by means of lightning rods which should be higher than the structures they are protecting.

N. W. Hartz, Mine Safety Appliance Company, presented the only technical paper of the session, “Instruments for Detection of Toxic and Explosive Gases.” The various sources of contaminating gases in and around power plants were described and the instruments for their detection explained.

The final paper of the session, “Control Rooms versus NEMA Enclosures for Electrical Equipment” by R. G. Rudrow, Atlas Powder Company, discussed the problem concerned with Class-I Group-D Classification to the extent of whether standard explosion-proof controls should be used or a separate control room be provided for the control of electric equipment. The size of the installation is a determining factor, as well as the cost, maintenance, and expansion factors.

A General Industry Applications Committee report was presented on “Maintaining Electrical Apparatus for Hazardous Locations.” This contains a number of precautions which should be observed in the maintenance of electric machinery.

Various Aspects of Machinery Insulation Covered Wednesday

The afternoon of January 24 a session was held in which the papers covered various aspects of machinery insulation. The session was presided over by J. W. Jones of the Philadelphia Electric Company.

First paper to be presented was “A Maintenance Inspection Program for Large Rotating Machines” by J. S. Johnson, Westinghouse Electric Corporation. The experience gained from a manufacturer’s maintenance inspection program was described, as well as general service experience with high-voltage machinery insulation. Inspection procedures, testing techniques, and equipment used in connection with the inspection program were outlined. During the discussion of this paper H. A. P. Langstaff of the West Penn Power Company described a failure in an old machine operated by his company and told what was being done to the failed equipment. He asked what tests could be performed on a similar machine to insure long life.

"Electrical Maintenance of Large Rotating Machines" was given by H. F. McCullough of General Electric Company. Mechanical inspection is performed to discover unnecessary vibration and similar faults; during periodic shutdown electrical inspection is performed. This includes looking for hot spots, inspection of end windings for movement and distortion, and looking for circumferential cracks in insulation of armature end windings. Other tests used are (1) insulation resistance test to discover the presence of dirt and moisture, (2) dielectric absorption test to indicate the condition of the insulation, (3) polarization index number, (4) surge test which means applying overvoltage to the turns to test turns insulation, (5) corona detection testing, and (6) overpotential test, which, it was maintained, is the only test to assure that a machine can be returned to service and give good performance.

"Routine Insulation Testing of Synchronous Machines," by L. F. Hunt and J. H. Vivian, both of Southern California Edison Company, was given by Mr. Hunt. Since 1945, when routine testing was first begun in the Southern California Edison Company, no winding has been lost in service, but ten faults were found in testing. A $25,000,000 investment is saved by cutting down the necessary amount of spinning equipment. The tests are made at 150 per cent rated alternating voltage. The closure after discussion was made by Mr. Vivian.

The next paper to be presented was "Detection of Turn-to-Turn Faults in Large High-Voltage Turbine Generators" by R. M. Sexton and R. J. Alke of the Westinghouse Electric Corporation. A method of finding turn-to-turn faults in stator windings by the use of a surge comparison tester has been investigated. The turn insulation is stressed several times operating voltage; and both copper-to-copper and arcing faults can be detected.

The next paper of the afternoon was a joint project of E. R. Morris of the Philadelphia Electric Company and R. D. Case of Westinghouse Electric Corporation. The title of their paper was "A-C and D-C Dielectric Breakdown Testing of a Large Turbine Generator Stator."

The program closed with the presentation by H. C. Marcroft of the Pennsylvania Water and Power Company of the paper "Turn-to-Turn Insulation Over-Potential Tests and General Dielectric Tests on Coils of a Turbo Generator." The failure of a coil in a turbogenerator after 23 years of service resulted in rewinding the generator and offered an opportunity for making tests of several types on the insulation. Insulation values with respect to insulation resistance, power factor, turn-to-turn dielectric strength, and coil-to-ground insulation strength were discussed.

Five Papers Presented at Session on Magnetic Amplifiers

An interesting, well-attended session on the very timely subject of magnetic amplifiers was held on Wednesday afternoon, January 24. The program consisted of two technical program papers and three conference papers. E. V. Weir, Naval Ordnance Laboratory, presided.

A "Progress Report of the AIEE Magnetic Amplifier Subcommittee" outlined the activities of that body to date. Formed in 1948, this group has been attempting to establish terms, definitions, and methods of expressing performance. The report included their proposals in this regard. The type of magnetic amplifier data most generally useful for application of these devices also was suggested. An example of the use of the proposed ratings and applications data was given.

A method for predicting the output currents of self-saturating magnetic amplifiers was outlined in a paper called "Steady-State Analysis of Self-Saturating Magnetic Amplifiers Based on Linear Approximations of the Magnetization Curve" by W. H. Esselman, Westinghouse Electric Corporation. How the load currents can be computed by assuming a 3-straight-line representation of the hysteresis loop was shown. A simplified procedure then was developed and applied to two half-wave amplifiers. Factors influencing the output of the full-wave and doubler circuits were discussed and illustrated. The computed values of the points on the transfer curves agreed with experimental results.

The first of the three conference papers of the session was called "The Transient Response of Magnetic Amplifiers" by L. A. Finzi and D. P. Chandler of Carnegie Institute of Technology, and D. C. Beaumariage, formerly of the same organization. It was concerned with the application of previously developed methods of analysis of magnetic amplifiers with gradually varying incremental permeability to the study of the general transient response of single-stage amplifiers. In the first part of the paper, curves were presented which described the transient response of magnetic amplifiers without feedback in general dimensionless form. The curves applied for transients in which the alternating voltage at the amplifier terminals is constant, and they also gave useful information for other actual operating conditions. In the second part, the analysis was extended to feedback amplifiers with a-c output operating in conditions of negligible commutation.

"Magnetic Amplifiers Using Ferrite Cores," by W. C. Johnson, Princeton University, was the title of the second conference paper. It described a magnetic amplifier using this type of core material. Characteristics of the unit under varying conditions of control and load were covered. Various means of increasing the frequency band width and their results were cited.

The final paper of the session was "Types of Magnetic Amplifiers—A Survey," by J. G. Miles, Engineering Research Associates, Inc. This paper dealt with a survey of the various kinds of magnetic amplifiers and outlined a scheme of using letter and number designations to codify them. Examples of how this coding system works were cited, and it was applied to many types of magnetic amplifiers, from the earliest types to the most recent.

Instruments and Measurements Session Held on Wednesday

The session covering instruments and measurements on January 24 was presided over by W. R. Clark, Leeds and Northrup Company. The first paper, "Frequency Compensation of A-C Instruments," was by J. H. Miller, Weston Electrical Instrument Corporation, and was presented by R. W. Gilbert of the same company. Through the use of a rigorous solution of the network of a voltmeter, frequency compensated by a capacitor in shunt with its series resistance, it has been possible to evaluate resulting errors at other frequencies for any given instrument. Data in curve form allow immediate estimate of error limits for any design and indicate those parameters which are controlling to any end requirement.

An Instruments and Measurements Committee report, "Marking of Varmeters," was presented by A. L. Carvill, General Electric Company. This is a compilation of a survey's results and shows that the greatest number of companies are in agreement on the use of In-0-Out markings, the use of the station bus as a reference point for line varmeter markings, and the use of the generator as a reference point for the generator varmeter.

"Winding Insulation Tester for D-C Armatures" was presented by F. H. Catlin and N. Rohats, General Electric Company. This is a surge generator for testing high-current windings of d-c armatures and employs ignitrons and a cathode-ray tube as indicator. Contact for testing is made to the commutator bars with a 2-handled mechanism; both handles must be pressed to operate interlock switches they contain.

The final technical paper of the session was presented by A. J. Corson and A. L. Nylander, both of the General Electric Company, and was entitled "A Hook-on Power Factor Meter." This instrument has a range of 0 lead to 0 lag power factor, 15 to 600 amperes, 100 to 600 volts on balanced 3-phase circuits. Its calibration accuracy is 0.02 power factor and it weighs 4 pounds.

Graduate Study in Electrical Engineering Discussed

Under the chairmanship of J. D. Ryder, University of Illinois, three conference papers were presented at the session on January 24.

E. W. Anderson, Iowa State College, presented the first paper entitled "Mathematics in Electrical Graduate Education." Mathematics, Doctor Anderson stated, should be used as a tool; the study of mathematics provides opportunity for development of the scientific method. Education as a whole should be useful; it must satisfy the needs of the students. Mathematics should be taught with an eye to its use, but this does not deny the function of pure mathematics.

"Graduate Examination Procedures" was the title of the paper presented by J. G. Brainerd, University of Pennsylvania. The three types of examinations that a student meets on the postgraduate level were discussed: the preadmission examination, an example of which is the Graduate Record Examination; course examinations, which the graduate student meets in his work at school; and the examinations which candidates for a particular degree face at the end of their course.

The third paper was presented by W. A Lewis, Illinois Institute of Technology It was entitled "The Importance of Graduate Work in the Power Field," and Mr. Lewis made four important points: 1. Electrica engineering graduates are less prepared fo work in the power field than they were generation ago. Because of the increase of technical requirements the problems of the work are more intense and what used to be considered advanced work is now performed every day. 2. Further graduate work is essential to meet the present and future problems of the power field. 3. There are few industries in this field which have time to provide educational programs as there is a shortage of power engineers. 4. More encouragement should be given to students to enter this phase of electrical engineering.

Session on Transmission Presents Data on High-Voltage Lines

In a Thursday morning session data obtained from tests on high-voltage lines was presented. The chairman of the session was I. W. Gross of the American Gas and Electric Company.

"Techniques of Corona Loss Measurement and Analysis—500-Kv Test Project of the American Gas and Electric Company" was the subject of a paper by O. Naef of the American Gas and Electric Service Corporation and R. L. Tremaine and A. R. Jones of the Westinghouse Electric Corporation. Mr. Naef presented the paper. In making the tests it was found that losses were not constant at one voltage; they were much higher when the voltage was first applied. For stable readings the conductors had to be aged at a voltage for about 25 minutes. Corona loss measurements had an accuracy of ±4 per cent at these voltages.

"Corona Investigation on Extra-High-Voltage Lines—500-Kv Test Project of the American Gas and Electric Company" was written by I. W. Gross and O. Naef of the American Gas and Electric Service Corporation and C. F. Wagner and R. L. Tremaine of Westinghouse Electric Corporation. The paper was presented by Mr. Wagner. The most notable characteristic of corona is its variability. Corona loss decreases with time after the conductor is first installed; it takes about seven months before the conductor is stabilized. Losses during foul weather fall in a higher zone than do the losses in fair weather. Constant results could have been obtained on polished conductors in a laboratory, but the outdoor conductor has dust and other contaminants on the surface, so a band of averages was obtained. See pages 224–30 of this issue of *Electrical Engineering* for the full text of the paper.

Next paper to be given was "Radio Influence Tests in Field and Laboratory—500-Kv Test Project of the American Gas and Electric Company" by G. D. Lippert and S. C. Bartlett of American Gas and Electric Service Corporation and W. E. Pakala and C. D. Fahrnkopf of Westinghouse Electric Corporation. Mr. Fahrnkopf made the presentation. Lines producing corona also cause radio influence which may interfere with radio reception. Measurements were made with conductors dry or subjected to artificial rain. Emphasis was made that good data can only be obtained from long term tests.

The next paper, "The 300/315-Kv Extra-High-Voltage Transmission System of the American Gas and Electric Company," by Philip Sporn, E. L. Peterson, I. W. Gross, and H. P. St. Clair, all of the American Gas and Electric Service Corporation, showed the use of the information contained in the preceeding papers in practice. Mr. Sporn gave the paper. To do a good job in long-term design of a system the technical knowledge of what the system will need must be obtained, and the economics of the system, the community, and the industry must be known. Some of the designs for the new 350-kv line of the American Gas and Electric Company were shown.

Last paper of the morning by H. P. St. Clair and E. L. Peterson, American Gas and Electric Service Corporation, was presented by Mr. St. Clair. The subject of the paper was "System Economics of Electric Power Transmission at Extra High Voltage." The system studied was a network type of system rather than one which involved long-distance transmission of large blocks of power. Network analyzer studies were made of the capabilities of lines at various distances. It was learned that the 315-kv level was the top for double-circuit construction. Factors against high-voltage lines are a high initial cost, too much capacity at first, double circuits cannot be used, large radio influence is present, loss of sleet-melting ability, and the limitation of the length of insulating strings. However, use of high voltages gives maximum utilization of rights of way, maximum utilization of the system, lower losses, and long range economy.

Developments in Radiation Detection Devices Discussed

Four conference papers on the latest developments in radiation detection devices were presented in the session held on January 25, over which Scott Helt, Allen B. Du Mont Laboratories, presided. The first paper, "Scintillation Counters," was given by George Morton, RCA Laboratories. He described the counters in which is incorporated a photomultiplier which can be used for examining the energy of incident particles and as a spectrometer. The transit time speed in the photomultiplier is of the order of 10^{-10} second.

The next paper, "Quenching and Lifetime of Geiger-Muller Counters," was given by J. B. H. Kuper, Brookhaven National Laboratory. After discussing the causes for tube failure and their symptoms, the author described a study of the length of shelf life of different counters filled with various gases; most of the tubes employ a gas in combination with argon and their shelf life is approximately 18 months. In regard to the counters' operating life, most failed after 10^7 to 10^8 counts.

D. L. Collins, Victoreen Instrument Company, gave a paper on "Electrometer Tubes." Many ordinary pentodes, as the *1LN5*, *6AK5*, *959*, and so forth, have been used for electrometers. In these the first grid is employed as a virtual cathode and the second grid as a control grid. A 2-tube circuit was described in which positive feedback gave a faster response. A mass spectrometer amplifier using negative feedback to increase its stability was explained and the characteristics of several electrometer tubes were given.

The final paper of the session, "Calibration of Radiation Detection Devices," was given by G. Failla of Columbia University. Two types of detection instruments were described which measure radiation harmful to people and which are calibrated in terms of damage to humans at daily intervals in small doses. One measures the radiation harmful at the skin's surface and the other at 5 centimeters beneath the skin's surface. The permissible weekly dosage for the skin is 0.5 roentgen and that for the blood-forming organs (5 centimeters under the skin) is 0.3 roentgen. Calibration should be made under operating conditions, and an accuracy of ±15 per cent is sufficiently close.

Power Tubes for Electronic Heating Discussed at Session

The latest developments in power vacuum tubes for electronic heating was the general subject of the session held January 25, over which W. G. Dow, University of Michigan, presided. The opening paper, "Tubes for Dielectric Heating at 915 Megacycles" by R. B. Nelson, General Electric Research Laboratories, was presented by P. W. Morse of the same company. This paper covered some of the new magnetrons with ratings of the order of 5 to 50 kw.

H. J. Dailey and C. H. Scullen, Westinghouse Electric Corporation, presented, "Selection and Application of Tubes for Induction and Dielectric Heating;" the paper was read by Mr. Scullen. After comparing the use of tubes in the broadcast field with those used for heating, ten requirements for heating tubes were given covering their power rating, cooling, and capabilities. Oscillator circuits for radio-frequency heating were discussed with recommendations for optimum operation.

H. B. Doolittle, Machlett Laboratories, next read his paper, "The Design of High-Power Vacuum Tubes for Industrial Heating Applications." Reasons for tube failure were given, these being short circuit between grid and cathode; warping of the filament; accidental loss of vacuum; overheated anodes; excessive grid dissipation; excessive gaseous condition due to overload. The construction of transmitter tubes was described with a 50-kw rating operating in the neighborhood of 100 megacycles.

The final paper of the session was given in two parts: the first by the author, W. Schmitt, Federal Telephone and Radio Corporation, and the last by G. Mortimer. The title was "A Very High Frequency High-Power Triode." In the design of triodes for frequencies of the order of 100 megacycles the construction must take into consideration factors such as the electron transit time, tube elements which are commensurate with the wave length, the interelectrode capacities, and the inductance of the leads to the elements. The first portion of the paper dealt with such details and a description of the triode which had been operated at 110 megacycles at 25 kw. The second portion of the paper considered the test circuit and procedure for this tube.

Industrial Power Systems Session Held on Thursday

J. S. Gault of the University of Michigan presided over the Industrial Power Systems session Thursday afternoon, January 25.

"High-Voltage Motor Starters Co-ordinated with Distribution Switchgear" was given by T. B. Montgomery of Allis-Chalmers Manufacturing Company. In this paper Mr. Montgomery differentiated between switchgear and control equipment. If the apparatus is above 5 kv and 50 kva it is switchgear; below, it is control equipment. The trend in design is toward air-immersed equipment. Old-fashioned air-break contactors were big and sprawly; now the contactors are small and the break takes place within the contactor with no danger of arcing to ground.

"Power Modernization of an Old Plant" was described by A. W. Howard of the General Electric Company. Before modernization, plant power was distributed at 4,000 volts by power cables through tunnels. It was fed radially from the power station to transformers next to each building. Some power was bought from the local power company. Vertical risers were installed in the building pilasters and open knife switches and fuse panels were in use. The modernization plan involved bringing power at high voltages as close to where it would be used as possible, as well as the installation of modern equipment.

T. O. Zittel of the Bethlehem Steel Company and R. M. Wilson of the General Electric Company wrote the paper "Power Distribution System Expansion—Bethlehem Steel Company, Lackawanna Plant," and it was presented by Mr. Zittel. The system described here had to be expanded to increase the facilities of a strip mill. As the local power company was already supplying all the 25-cycle power it could, the expansion involved breaking away from a 25-cycle system. Instead of using a 60/25-cycle substation, a completely new 60-cycle system at 13.8 kv was installed.

The paper, "Power Distribution System of the United States Government Accounting Office Building, Washington, D. C.," was prepared by F. J. Muller, Public Building Service, and D. S. Brereton, General Electric Company, and was presented by Mr. Brereton. It described the power distribution system in the second largest building in the world. The building has seven stories and two basements, 2,000,000 square feet of floor space, fluorescent lighting, and is completely air-conditioned.

Session Features Papers on Noise From Fluorescent Lamp Ballasts

A session held during the afternoon of January 25 on the measurement and control of audible noise from fluorescent lamp ballasts, with E. H. Salter presiding, brought together reports of work being done on the problem in three different areas. The presentations and the discussions brought out that the problem arises in connection with installations where a low noise level is desired, such as in libraries, television studios, private offices, and in homes.

The problem of measurement of audible noise from fluorescent lamp ballasts is a complex one which deals with something that the ear can detect but the average sound-level meter will not indicate. The ballast, an electromagnetic device, has noise generated within it which is transmitted to the fixture by mechanical vibration and by air-borne noise which impinges on the fixture surfaces. One of the papers presented a different approach to the problem through the measurement of vibration rather than the measurement of the noise.

No definite conclusions were indicated but the session brought about a better understanding of the problem between the various interested groups: lamp, fixture, and ballast manufacturers.

Recent Information on Electric Generating Equipment Presented

The object of the Friday morning session on power generation was to present recent information on electric generating equipment. H. R. Harris of The Detroit Edison Company presided.

"Progress in the Development of Large Turbine Generators," which was prepared by E. D. Huntley and H. D. Taylor of the General Electric Company, was presented by Mr. Taylor. Among improvements which have been introduced recently in large generators are vertical coolers to improve ventilation, more uniform magnetic material with better magnetic properties and oriented strip steel, which improve the magnetic properties of the equipment. Machine growth has been rapid; the 2-pole 3,600-rpm machine growth jumped greatly in 1935 with the introduction of hydrogen cooling. The latest turbine sold by the General Electric Company was a 176,000-kva generator for use in Philadelphia.

In the discussion following this paper Sterling Beckwith of Allis-Chalmers Manufacturing Company traced some of the developments of machines smaller than those covered in the paper.

Next on the program was "Modern Practice in the Balancing of Large Turbine-Generator Rotors" by C. M. Laffoon, A. C. Hagg, C. H. Janthey, and P. R. Heller, all of Westinghouse Electric Corporation. Mr. Heller gave the paper. To balance the rotor the rotor material is first inspected; then the rotor is operated and vibration readings are taken; finally the rotor is heated in a heater box and balanced at 3,600 rpm. In this way the rotor is balanced in a few days instead of the three to five weeks that was usual a few years ago.

"Progress and Needed Improvements to Electric Power Generating Stations and Machines," prepared by I. E. Moultrop, Boston Edison Company (retired), and G. A. Orrok, Jr., Boston Edison Company, was presented by Mr. Moultrop. Power generation was reviewed from the first generating station in New York in 1880 to the present. At the early Pearl Street Station boilers operated at 100 pounds pressure, while modern turbines use steam at 1,200 pounds pressure and 900 degrees Fahrenheit. Suggestions for the future showed the need for much larger units, for instance, 200,000-kw turbogenerators, steam cycles with higher temperatures and metals that will withstand higher temperatures, elimination of heat loss in condensers, and lower cost underground construction.

T. B. Montgomery, R. C. Moore, W. L. Ringland, and L. T. Rosenberg, all of Allis-Chalmers Manufacturing Company, prepared the paper "Progress in Electrical Machinery and Control for Power System Service," which was presented by Mr. Ringland. Engineering progress in electric machinery has resulted in improved machine performance for the owner and more efficient utilization of materials by the manufacturer. Greater convenience is provided in operation and maintenance, and improved ventilation and better control of losses have permitted reductions in size for many output ratings.

The final paper of the session was "Recent Improvements Made to Electric Power Generating Machines and Equipment" by M. R. Lory and J. W. Batchelor of the Westinghouse Electric Corporation. Improvements made in turbine generators recently include better insulation and copper, which increase life expectancy, increased hydrogen pressure, which increases the capacity of the machine, and incorporating weatherproof features in the design of the machine so the generators can be installed in outdoor locations if desired.

Two Sessions on Electron Tubes, Devices, and Techniques Held

On the last day of the meeting two technical sessions were devoted to the latest developments in the electronic field. At the morning session tubes were considered and over this W. C. White, General Electric Company, presided. A. W. Coolidge, Jr., General Electric Company, presented "A High-Current Thyratron," which has forward and inverse anode voltage ratings of 1,500 volts and peak and average current ratings of 150 and 12.5 amperes respectively. Anode and grid elements are integral parts of the tube and are cooled by convection as well as radiation. Arrangement of the grid-anode structure permits operation with a high commutation factor rating and provides a resistance to gas clean-up.

"A Tunable Miniature Magnetron" was the subject of H. W. A. Chalberg, General Electric Company. This miniature magnetron oscillator, contained in a glass envelope 11/16 inch in diameter, was designed to produce an output of 250 milliwatts in the 300- to 1,000-megacycle range. The elements are eight vanes fastened alternately to two end rings supported by mica spacers and the field is provided by a circular magnet placed around the outside of the tube.

The final paper of the morning session was presented by J. H. Reisner, Radio Corporation of America, and was entitled "A Permanent Magnet Electron Microscope." Although this simplified electron microscope is small enough to be desk-mounted, it has a resolution of 100 angstroms. Its magnetic lenses are energized by permanent magnets and an accelerating voltage of 50 kv is varied over a narrow range to provide means of focus. Direct magnifications of 1,500, 3,000, and 6,000 are possible and photographic images can be enlarged up to ten times.

The afternoon session was devoted to new electronic devices and techniques and E. M. Boone, Ohio State University, was chairman. The first paper, "A Metal Evaporator Using High-Frequency Induction Heating," was given by R. G. Picard and J. E. Joy, Radio Corporation of America, and read by the former. A radio-frequency generator is used to supply power for heating metal by induction through a special coupling coil. A new type of feed through bushings was designed so that the radio-frequency power could be introduced into the vacuum enclosure where ccessful evaporations of small charges of etal have been effected. The deposit is free f contaminating materials which occur dur- ng evaporation from heated filaments.

“Use of Diodes as Logarithmic Elements Measuring and Control Equipment” was resented by W. M. Grim, Jr., Massachu- etts Institute of Technology. For negative alues of plate voltage, the plate current of diode increases exponentially with the plate oltage. This region of operation makes vailable a logarithmic element good over bout eight decades of current. An applica- ion of the diode is in a logarithmic electrom- ter which is capable of measuring current rom 10^{-18} to 10^{-4} ampere.

N. G. Branson, Branson Instruments, Inc., lemonstrated his equipment during the read- ng of his paper, “Measurement of Metal Vall Thickness from One Side by the Ultra- onic Resonance Method.” A vibrating uartz crystal is placed on one side of the netal and an ultrasonic wave is transmitted nto the material. At certain frequencies vhen the transmitted and reflected waves are n phase, the amplitude of the wave in the netal increases, which is a resonant condi- ion. This occurs at a frequency inversely roportional to the thickness and directly roportional to the velocity of sound in the netal, which is known. The fundamental requency producing resonance is a measure f an unknown thickness.

The final paper of the session was “The Sona-Stretcher” by H. R. Foster, E. E. Crump, and J. L. Gogorth, Kay Electric Company. This is an instrument which engthens the time scale of recorded sounds by a 2-to-1 ratio but does not change the requency distribution. It is used for the tudy of speech.

ight Papers Presented at Session on Heavy Traction

On January 26 a series of three papers vhich dealt with the selection of equipment or multiple-unit cars including the ad- antages of the ignitron rectifier for motive ower, a description of the new multiple- nit car motor with resistance leads from he armature windings for the Pennsylvania Railroad, and the car control equipment vas presented by W. M. Hutchison of the Vestinghouse Electric Corporation. These resentations were followed by a series of hree papers which dealt with the advantages f 4-motor multiple-unit car equipment uch as the new New York Central multiple- nit cars, the design features of a-c multiple- nit car motors, and the car control equip- nent, all presented by R. A. Williamson of he General Electric Company. Notable mong the several improvements brought bout are the methods of flexible mounting f motors suspended from the trucks rather han axle-hung and the elimination of the nsprung weight as well as a new motor- riven cam type of controller.

In conclusion, the presiding officer, H. . Brown, commented on both groups of apers as follows: in spite of the fact that lectric traction is 45 years old, the papers ndicate that considerable progress has been nade which will result in greater passenger omfort through more efficient control of the notors and electric equipment.

In another paper, “A New Train Per- rmance Calculator” was described by S. V. Smith of the Pennsylvania Railroad. The calculator was developed to compute and record mechanically and quickly information required by a railroad to determine the economics, application, proper size, and tonnage ratings for new types of motive power. The paper served as a good demonstration of how the railway electrical engineer is using the latest calculating and recording devices for the rapid solution of some of his most laborious problems.

In still another paper, “A Modern Cab Signaling and Train Control System for Railroads” was described by L. R. Allison of the Union Switch and Signal Company. This paper served to bring the Institute up-to-date on the most modern safety devices in the control of railroad traffic.

Session on Color Television at Winter General Meeting

One session held Friday afternoon was concerned with the timely topic of color television. J. B. Coleman of the Radio Corporation of America was chairman of the session.

Studies have been made of the feasibility of wider commercial use of ultrahigh-frequency television. A summary of one such study was presented by R. G. Clapp of Philco Corporation in the paper “U. H. F. Television Reception at Bridgeport.” This study was necessary to determine the potential market for receivers in ultrahigh-frequency regions, the service facilities necessary for such an area, and the transmitting equipment and conditions necessary to make such an installation successful. It was found that wooded areas and buildings absorb ultrahigh-frequency signals more than very-high-frequency signals.

“Some Phases of the United States Color Television Standards” were discussed by P. C. Goldmark, Columbia Broadcasting System, Inc. Doctor Goldmark maintained that the color standards now in use, which are specified in terms of a set of receiver standards, are not definite enough and they should be specified in terms of transmitter standards. It was suggested that standards specify that major energy for red be between 550 and 660 millimicrons, for blue between 410 and 500 millimicrons, and for green between 490 and 600 millimicrons.

H. R. Smith, A. L. Olson, and R. F. Cotellessa of Allen B. Du Mont Laboratories, Inc., submitted the paper “A Color Television System for Industry,” which was given by Mr. Olson. The system described was a high-definition nonbroadcasting system for military, medical, or merchandizing use. The set has a mechanical rotating color wheel, and it can be used by modifying existing equipment. Bandwidth is 18 megacycles per second. The system uses the same number of units as are used in a standard black-and-white camera chain.

“Fundamentals of Color Television and Their Application Today” was given by A. V. Loughren of Hazeltine Electronics Corporation. It has been maintained that three times the bandwidth of black and white must be used to give good color because three times the information must be transmitted, but this paper advanced the theory that color can be described by a different approach, visual brightness, hue, and saturation, and a wide band is needed for brightness, but narrow ones can be used to transmit hue and saturation. The theories presented were illustrated by the use of slides which had been obtained from pictures on different television screens.

Papers on Rapid-Transit Cars Read at Light Traction Session

During the afternoon of the last day of the meeting, a series of five papers in the field of light traction was presented. H. F. Brown presided over the session. The papers dealt with the studies of power supply and the electric equipment and performance of lightweight rapid-transit cars. The progress reported closely paralleled that which was noted at the heavy traction session in the morning, as the papers showed how the knowledge gained from the development of the Presidents' Conference Committee cars has been applied to the design of modern rapid-transit cars. The two papers on the trolley-coach power supply were timely in that they indicated economics and the method of power supply to this type of vehicle which is rapidly supplanting the urban type of rail vehicle.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

General Applications Division

Committee on Marine Transportation. (*O. A. Wilde, Chairman; J. B. Feder, Vice-Chairman; W. N. Zippler, Secretary.*) A meeting of the committee was held on December 15, 1950, at which time the subcommittees submitted reports covering additions and changes to be made in Standard Number *45*. It was decided that the committee would request manufacturers of galley equipment used on ships to work with the committee in establishing standards for such equipment. Certain features of electric galley equipment, quite acceptable for land, have been found to be objectionable on ships.

A draft of marine sections of “Definitions of Electrical Terms” was accepted for submittal to American Standards Association Sectional Committee *C-42*.

Agreement was reached on revised ratings for marine electric cables which, in general, will somewhat increase allowable current-carrying capacities. Strong recommendations are to be included in Standard Number *45* that cables grouped together should be kept to as small a number as possible.

The problem of providing adequate cargo pump room lighting on tankers was discussed. It was noted that British shipbuilders also have difficulty in this respect. Recommendations are to be made in Standard Number *45* which will first be correlated with findings of the American Petroleum Institute.

It was noted that the National Fire Protection Association (NFPA) rules cover electric plants on small boats up to 32 volts, and Standard Number *45* contains at present rules for shipboard electric plants of 115 volts and over. A special subcommittee was appointed to review present practices on craft with intermediate voltage electric plants and explore the necessity, desirability, and feasibility of extending Standard Number *45* to include recommendations for such vessels. The subcommittee chairman is also a member of the equivalent NFPA subcommittee, assuring proper liaison.

Industry Division

Committee on Chemical, Electrochemical, and Electrothermal Applications. (*L. W. Roush, Chairman; M. A. Hyde, Jr., Secretary.*) A meeting of this committee was held during the Winter General Meeting in New York to plan participation in the programs of coming AIEE meetings. Particular attention was given to a session on "The Petroleum Industry in Canada" planned for the 1951 Summer General Meeting in Toronto.

For the Winter General Meeting the Chemical Industry Subcommittee arranged a session on "The Installation of Electric Cables in Chemical Plants" and the Cathodic Protection Subcommittee scheduled a session on "Cathodic Protection."

At the Fall General Meeting in 1950, the Cathodic Protection Subcommittee presented a program of five papers on the subject of Cathodic Protection, attended by over 100 persons and received with considerable interest as indicated by the questions and discussion. Among the subjects covered in a very active meeting of this subcommittee were: the complementary relationship of this committee with the National Association of Corrosion Engineers, consideration of necessary basic work and certain specific problems now existing in this field, the publication by AIEE of information including a manual on cathodic protection, stimulation of research, and the scheduling of papers for coming AIEE meetings.

Power Division

Fault Limiting Devices Subcommittee of Protective Devices Committee. (*E. G. Norell, Chairman.*) In 1947 the Fault Limiting Devices Subcommittee made a survey of grounding practices on power systems. An analysis of the results of this survey showed a need for some kind of manual or guide on grounding practices for generator, transmission, and distribution systems.

The proper way to ground the neutral or neutrals of a 3-phase electric system has been a much-debated subject. Resistance, reactance, solidly grounded, and isolated neutrals have all been tried and it has been demonstrated in practice that workable systems are available with any of the various methods that might be used. It is therefore recognized that there is no universal answer to the neutral grounding problem. It is possible, however, to establish certain criteria that are desirable and once the desired objectives are decided upon, it should be relatively simple to select the method of grounding that best fulfills the requirements.

As of this date three guides have been prepared: Application Guide on Methods of Grounding Transmission Systems; Application Guide for Grounding of Synchronous Generator Systems; and Guide for Application of Ground Fault Neutralizers.

These guides have been issued on a 1-year trial basis with the intention that they would be revised and put in final form at the end of the trial period. The working groups are very anxious to receive comments and suggestions from the AIEE membership so that the guides will represent current practice (see stories in *EE, Feb '51, pp 166–7*).

Science and Electronics Division

Joint Subcommittee on Electronic Instruments. (*Rudolf Feldt, Chairman; W. H. Tidd, Vice-Chairman; P. K. McElroy, Secretary.*) The Joint Subcommittee on Electronic Instruments is currently working on a set of uniform methods for specifying performance of various electronic instruments. This work has been concentrated on cathode-ray instruments, handled by a Task Group under the Chairmanship of Mr. R. Feldt, and on vacuum-tube voltmeters by a group headed by Mr. C. H. Hastings. This latter group has made substantial progress recently, and it is expected that this, in turn, will be beneficial to work on cathode-ray instruments. As soon as the progress on these two types of instruments has gone far enough, it is intended to extend the activity of the Committee to other groups of electronic instruments, such as standard signal generators and test oscillators.

Joint Subcommittee on Telemetering and Supervisory Control. (*W. J. Mayo-Wells, Chairman; J. L. McKee, Secretary.*) With the publication of the 200-page volume of the proceedings, the results of the jointly sponsored AIEE—National Telemetering Forum Conference can be adjudged. It is confidently believed that the conference demonstrated the value to both groups (mobile and point-to-point) of learning more about each other's developments and techniques. Supervisory Control was purposely omitted from the program as a different, though closely related, subject. It is intended that a second conference at a future date may include papers on control from both camps

The work of the Subcommittee on Telemetering Terms has continued, and recently the members have been organized into three regional groups. Each group will consult together on the same set of terms, and a co-ordinating committee will summarize the group replies for circulation. While there will be no actual representation on the similar committees of other national societies, other than those of the Institute of Radio Engineers, close liaison will be maintained with their activities.

The Joint Subcommittee met in New York prior to the Instruments and Measurements Committee luncheon meeting during the Winter General Meeting.

AIEE PERSONALITIES.....

Everett S. Lee (A '20, M '28, F '30), executive engineer, General Engineering and Consulting Laboratory, General Electric Company, Schenectady, N. Y., has been appointed editor of the *General Electric Review*. Mr. Lee, a Past President of the AIEE, was born in Chicago, Ill., on November 19, 1891. He was graduated from the University of Illinois in 1913 with a bachelor of science degree in electrical engineering and received a master of science degree in electrical engineering from Union College in 1915. Following his graduation, Mr. Lee joined General Electric Company and except for military leave during World War I he has been associated continuously with the company. In 1919 he returned to General Electric as division engineer on instruments and measurements in the General Engineering Laboratory. In 192 he was made assistant engineer of tha laboratory, and three years later he wa made engineer. In 1945, the Genera Engineering Laboratory and the Consultin Laboratory were combined with Mr. Lee a executive engineer. Mr. Lee has activel served the AIEE on 19 national committee and has been chairman of six of these fo one or more years. In addition, he ha been a member of two co-ordinating committees and 10 special committees. (H served as AIEE representative on the National Research Council and the Engineerin Council for Professional Development o which he was chairman from 1943 to 194 Mr. Lee is also a Fellow of The America Society of Mechanical Engineers, a senio member of the Institute of Radio Engineer a member of the American Society fo Engineering Education, National Societ of Professional Engineers, Eta Kappa Nu Tau Beta Pi, and Sigma Xi.

E. S. Lee

H. C. Coleman (A '18, F '48), manage Marine and Aviation Section, Industr Engineering Department, Westinghou Electric Corporation, East Pittsburgh, Pa has been appointed manager of the Company's Industry Engineering Departmen Born in Footville, Ohio, on January 2 1893, he was graduated from Ohio Sta

H. C. Coleman

P. L. Alger

N. B. Hinson

H. E. Farrer

Jniversity in 1916 with a degree of bachelor f electrical engineering. In that year he ntered the graduate student course of the Vestinghouse Electric Corporation and in 917 became an application engineer in the eneral Engineering Department. In 1934 e was appointed manager of Marine Engineering under the General Engineering Department which was extended to include viation Engineering in 1945. Mr. Cole-nan is the author of many technical articles nd papers on electric propulsion. In 1942 e received the Westinghouse Order of Merit or his "pioneering work and orginality in he application of electricity aboard ship." The United States Navy awarded him its Certificate of Commendation in 1947 for his utstanding accomplishments during World Var II, when he worked closely with the Vavy both in the United States and in Europe. Mr. Coleman is also a member f the Society of Naval Architects and Marine Engineers, the American Society of Vaval Engineers, and Sigma Xi. Mr. Coleman has actively served the Institute on he following committees: Marine Transortation (1927–46, Chairman 1933–35, 948–51); Technical Program (1933–35, 948–50); General Applications Co-ordiation (1948–50, Chairman, 1948–49); Planning and Co-ordination (1948–50); ward of Institute Prizes (1948–50); and Technical Advisory Committee (1950–51).

. L. Alger (A '17, F '30), consulting ngineer, Apparatus Department, General lectric Company, Schenectady, N. Y., has een appointed consulting engineer to the mall and Medium Motor Divisions of the pparatus Department. He was born on anuary 27, 1894, in Washington, D. C., nd received the degrees of bachelor of rts in 1912 from St. John's College, bachelor f science from Massachusetts Institute of Technology (MIT) in 1915, and master of cience in 1920 from Union College. After year as an assistant instructor at MIT he ntered the General Electric Company test ourse. From 1917 to 1919 Mr. Alger rved with the United States Army, and then ntered the Induction Motor Engineering epartment of the General Electric Comany, Schenectady, N. Y. In 1924 he was ansferred to the A-C Engineering Deartment, and in 1930 he was appointed as aff assistant to the Vice-President in harge of Engineering. Mr. Alger is the uthor of many technical articles. He was Director of the AIEE from 1944 to 1948 nd has actively served on the following Institute committees: Electrical Machinery (1926–42, Chairman 1929–32); Technical Program (1929–32, 1939–45, Chairman 1941–43); Lamme Medal (1932–35); Standards (1932–44); Planning and Co-ordination (1941–43, 1945–47); Award of Institute Prizes (1941–44, Chairman 1941–43); Board of Examiners (1944–47); Executive (1944–47); Edison Medal (1944–48); Education (1944–45); Research (1945–47); and Management (1948–51).

N. B. Hinson (A '19, M '26, F '35), Vice-President and Executive Engineer, Southern California Edison Company, Los Angeles, Calif., has retired after 44 years of continuous service. Born in Evansville, Ind., on December 25, 1885, Mr. Hinson joined the Edison Electric Company (now the Southern California Edison Company) in 1906 as a testman. He successively became assistant superintendent of distribution, assistant manager of operation, and in 1934 he was appointed chief engineer of the company and Chairman of the Engineering Committee. Since 1943 he has been Chairman of the Pacific Southwest Power Interchange Committee which directed the generation and utilization of electric power for war industry in the Los Angeles area. He will continue in this post. Mr. Hinson has been an active member of the Institute and has served as a national director since 1949. AIEE committees he has served on include the following: Power Generation (1935–41); Special Committee on Registration of Engineers (1942–46); Constitution and By-laws (Chairman 1949–51); Planning and Co-ordination (1949–50); Safety (1949–51). He is also a member of Tau Beta Pi.

H. E. Farrer (A '21, M '46), secretary, New York Electrical Society, New York, N. Y., has become associated with the American Standards Association, New York, N. Y. In 1949 Mr. Farrer retired as assistant to the secretary of the AIEE, and secretary of both the AIEE Standards Committee and the AIEE Board of Examiners. He had been a member of the AIEE headquarters staff in New York, N. Y., since 1915. Born in Brooklyn, N. Y., October 4, 1883, Mr. Farrer received his degree in electrical engineering from Columbia University in 1908. Before joining the staff of the AIEE, Mr. Farrer was associated with the Sprague Electric Works of the General Electric Company where he worked as technical assistant in advertising, publications, and sales. In 1915 Mr. Farrer joined the AIEE headquarters staff as assistant to the editor of AIEE publications. Three years later he was appointed secretary to the Board of Examiners, and in 1923 he added the duties of the secretary of the Standards Committee to his responsibilities. As part of his duties in the latter capacity Mr. Farrer also acted as AIEE representative to the Electrical Standards Committee of the American Standards Association. Mr. Farrer was also a director of the board administrating the New York City office of the Engineering Societies Personnel Service.

D. L. Herr (M '47), head, Section for Guided Missile Research and Development, Hughes Aircraft Company, Culver City, Calif., has been awarded one of the A. Cressy Morrison prizes for 1950 by the New York Academy of Sciences for his paper on "A Theorem in Electromagnetics, with Useful Applications to Computing Devices." Mr. Herr was graduated from the University of Pennsylvania in 1937 with a bachelor of science degree in electrical engineering. In 1938–39 he was selected National Tau Beta Pi Fellow and did advanced work in network analysis and synthesis, theoretical physics, and applied mathematics at the Massachusetts Institute of Technology. Mr. Herr served as Officer-in-Charge of the Electrical Minesweeping Section of the Bureau of Ships, United States Navy, during World War II. After the war, Mr. Herr was assistant to the Vice-President in charge of engineering of the Control Instrument Company, Brooklyn, N. Y., and then a senior engineer of the Reeves Instrument Corporation, New York, N. Y. He is also a member of the Institute of Radio Engineers, New York Academy of Sciences, American Society of Mechanical Engineers, American Association for the Advancement of Science, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu.

A. V. Feigenbaum (A '46), Director of Training Activities, Apparatus Department, General Electric Company, Pittsfield, Mass., has been appointed to the staff of the Aircraft Gas Turbine Division, Lynn, Mass. Mr. Feigenbaum was graduated from Union College in 1942 with a Bachelor of Science degree in engineering and in 1948 he received his Master of Science degree in business and engineering administration from Massachusetts Institute of Technology. He is a member of The American Society of Mechanical Engineers.

H. R. Skifter (M '46), President, Airborne Instruments Laboratories, Inc., Mineola, N. Y., has been appointed Chairman of the Committee on Navigation of the Department of Defense Research and Development Board. Dr. Skifter, who has been a member and vice-chairman of the committee since its formation in June 1948, has been serving as acting chairman for the past six months. During World War II he was associate director, Airborne Instruments Laboratory of Columbia University, Division of Research.

J. B. Clapp (A '24, M '26), Sales Engineer, The Thomas & Betts Company, Elizabeth, N. J., has been appointed sales manager of the Safety Mineral Insulated Wiring Division of the General Cable Corporation, Perth Amboy, N. J. Mr. Clapp studied at the Newark Technical School and his experience includes association with the Copperweld Steel Company, Glassport, Pa., and James R. Kearney Corporation, St. Louis, Mo.

G. A. Matthews (A '40, M '42), inspection and equipment engineer, The Detroit Edison Company, Detroit, Mich., has retired after 34 years' service. Born on December 4, 1885, at Clinton, Mass., his career started in the electric utility business with the Connecticut Lighting and Railway Company, Waterbury, Conn. He became associated with the Detroit Edison Company in 1916, first in the electrical construction field, later in maintenance, and finally in inspection and development. Mr. Matthews is responsible for numerous improvements in high-voltage transformers and switchgear.

W. J. Delehanty (A '17, M '24), local manager, Construction Materials Department, General Electric Company, San Francisco, Calif., has been appointed manager of the Wire and Cable plant of General Electric Company at Oakland, Calif. In this capacity, Mr. Delehanty is responsible for the management of engineering, manufacturing, and commercial operations of the Oakland plant. Mr. Delehanty became associated with General Electric in 1910.

J. B. Clark (A '46), export sales manager, Electric Storage Battery Company, New York, N. Y., has been appointed Vice-President and Director of the newly established Electric Storage Battery International Corporation. This company has been formed to carry on the foreign business of the parent organization, the Electric Storage Battery Company. Mr. Clark began his career with the company in 1929 as a service engineer. In 1946 he was placed in charge of motive power sales in New York and four years later he was named export sales manager.

N. W. Landis (A '47), district manager, Allis-Chalmers Manufacturing Company, Syracuse, N. Y., has been named manager of Allis-Chalmers' Detroit district office. Mr. Landis had been manager of the company's Syracuse office since 1946. He is an electrical engineering graduate of Northwestern University and has been connected with Allis-Chalmers since 1938.

G. W. Vinal (M '19, F '42), retired, has been named engineering consultant and adviser to The Electric Storage Battery Company. Dr. Vinal, whose work in developing electrical standards and the storage battery, has earned him many national and international awards, recently retired as chief of the National Bureau of Standards' electrochemistry section after more than 42 years with the government.

O. W. Gatchell (M '37), chief engineer, Frank Horton and Company, Lamar, Mo., has joined the engineering staff of Ebasco Services, Inc., New York, N. Y., and has been assigned to Athens, Greece, in connection with the 150-kv transmission system of the power project for the Greek government. Mr. Gatchell served on the AIEE Power Transmission and Distribution Committee from 1941 to 1943.

V. B. Haas, Jr. (A '50), assistant professor of electrical engineering, North Dakota State College, Fargo, N. Dak., has been appointed assistant professor of electrical engineering at the University of Connecticut, Storrs, Conn. Mr. Haas also has been on the faculty of the Massachusetts Institute of Technology, Cambridge, Mass. Before entering teaching Mr. Haas was employed by the General Electric Company.

Zay Jeffries (M '36, F '42) retired, has been elected to the Board of Directors of the Cleveland Electric Illuminating Company, Cleveland, Ohio. Doctor Jeffries was a Vice-President of the General Electric Company and general manager of the Chemical Department, Pittsfield, Mass., until his retirement in 1949.

Hector Sleeman (M '27, F '36), Consulting Engineer, Melbourne, Australia, has been appointed manager of The Townsville Regional Electricity Board. Prior to the fall of Rangoon in 1942, Mr. Sleeman was chief engineer of the Rangoon Electric Tramway and Supply Company, Ltd. During the war he served in India on the staff of the Royal Electrical and Mechanical Engineers.

Y. H. Ku (A '27, M '34, F '45), President, Central University, Chungking, China, has been appointed as visiting professor of electrical engineering at Massachusetts Institute of Technology, Cambridge, Mass. Dr. Ku was formerly Dean of Engineering College, Tsing Hua University, Peiping, and is also Past President of the Chinese Institute of Electrical Engineers.

I. L. Auerbach (A '48), engineer, Electronic Tube Corporation, Philadelphia, Pa., has joined the staff of the research division of the Burroughs Adding Machine Company Philadelphia, Pa., as a research engineer. Mr. Auerbach is also a member of the Institute of Radio Engineers and Eta Kappa Nu.

Herman Epstein (A '48), instructor, Department of Electrical Engineering, Yale University, New Haven, Conn., has joined the research division of the Burroughs Adding Machine Company, Philadelphia Pa., as an associate research engineer in the Special Devices Department. He is also a member of the Institute of Radio Engineers, Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

Carl Beckman (A '41), project engineer Control Instrument Company, Bendix Aviation Corporation, Teterboro, N. J., has joined the staff of the research division of the Burroughs Adding Machine Company Philadelphia, Pa., as a research engineer Mr. Beckman's previous experience includes being a member of the engineering staff o the Westinghouse Electric Corporation. He is also a member of the Institute of Radio Engineers.

A. L. Thurman (A '38, M '45), assistant vice-president, Aetna-Standard Engineering Company, Youngstown, Ohio, has been elected President of the Mahoning Valley Society of Professional Engineers, loca chapter of the National Society of Professional Engineers. Mr. Thurman is also a member of the Executive Committee o the Sharon Section of the AIEE.

W. H. Haines (A '17, M '25), Vice-President and Sales Manager, Electric Specialty Company, Stamford, Conn., has been appointed General Manager. Mr. Haines has been associated with this company for nearly 30 years.

L. S. Lauchland (A '36, M '47), Assistant Professor of Electrical Engineering, University of Toronto, Ontario, Canada, has resigned as Secretary of the Toronto Section He is now Secretary-Treasurer for the year 1950–51.

C. W. Leihy (A '30, M '38), Executive Vice-President, Electrical Publications, Inc. Chicago, Ill., has assumed the duties o publisher of *Electric Light and Power* and *Electrical Dealer* magazines.

W. S. Jones (A '48), Representative in charge of Glendale (Calif.) Office, Rockbestos Products Corporation, has been appointed District Manager of a new district office in New Orleans, La.

F. H. Woodruff (A '50), Allis-Chalmers Manufacturing Company, Milwaukee, Wis. has been named a sales representative in the company's Memphis, Tenn., district office.

OBITUARY • • • • •

Sir Frank Gill (A '03, M '11, F '13, Member for Life), K.C.M.G., O.B.E., Vice-President International Standard Electric Corporation London, England, died on October 25, 1950 Mr. Gill was born at Castledown in the Isl of Man, United Kingdom, on October 1866, and attended technical classes at the Royal College of Science, Dublin, and University College, Liverpool. He began hi work in telephony in 1884 when he entered e service of the Telephone Company of land. In 1902 he was called to London fill the position of engineer-in-chief of the tional Telephone Company, and he mained in this post until 1912. During orld War I Mr. Gill served in various pacities with the government and for these vices he was made an Officer of the Order the British Empire (O.B.E.). In 1919 he cepted the post of European chief engineer the International Western Electric Com- ny, the name of that company being anged to the International Standard Elec- c Corporation in 1925. He was elected ce-President of the corporation in 1929, d the same year he was called to Shanghai, ina, where he undertook the reconstruc- n of the telephone system of the Shanghai lephone Company, remaining until 1934. 1922 he was elected President of the Insti- tion of Electrical Engineers of which he d been a member since 1891. In 1941 as reward for outstanding achievement he s appointed by His Majesty the King to a Knight Commander of the Most Dis- guished Order of St. Michael and St. orge (K.C.M.G.) for services in the de- lopment of the telephone industry and of ernational telephony.

ugo Emil Eisenmenger (A '11, M '30, ember for Life), retired, died on August , 1950. He was born on July 7, 1874, in enna, Austria, and was graduated from e Technical University of that city. From 06 to 1907 Mr. Eisenmenger was chief gineer of construction and operation of the itish Government Central Station at artoum, Central Africa. The next two ars were spent in Japan where Mr. Eisen- nger was chief engineer and representa- e of a German electrical firm. He then me to the United States and from 1909 to 19 Mr. Eisenmenger was assistant to the ief engineer of the National Lamp Works General Electric Company, Nela Park, eveland, Ohio. He joined Consolidated ison Company, Mount Vernon, N. Y., in 21 and remained with this company until retirment.

ank R. Hannon (A '20), President, nnon Electric Company, Canton, Ohio, d on January 5, 1951. Born on June 19, 92, in Fort Recovery, Ohio, Mr. Hannon s educated in Canton and became asso- ted with the Physicians and Dentists rporation as factory superintendent in 14. His experience also included associa- n with the Wilson and Painter Electric mpany, also in Canton, and the Ordnance partment, United States Government, ritan Arsenal, Metuchen, N. J. In 1926 . Hannon founded the Hannon Electric mpany and was President and Manager til his death. He was well known as a igner and developer of many products for lustry, including the Hanco kiln fans and een heaters. Mr. Hannon was also a mber of the National Industrial Service sociation and the National Association of ofessional Engineers.

lliam Ronald Kinnaird (A '43), assistant gineer, Marlborough Electric Power Board, nheim, New Zealand, died on October 19, 50. Mr. Kinnaird was born on October 30, 1904, in New Zealand, and received his training in electrical engineering from the International Correspondence Schools. After serving as an apprentice to the wiring trade, Mr. Kinnaird became registered under the New Zealand Government and, after several years' experience as a power station engineer, in 1933 he was appointed electrical inspector to the Marlborough Electric Power Board. In 1938 Mr. Kinnaird was promoted to the position of chief inspector.

Robert Jackson Bushnell (A '36, M '50), assistant superintendent, Service and Meter Department, Commonwealth Edison Company, Chicago, Ill., died on December 5, 1950. Mr. Bushnell was born on February 23, 1910, at Hinsdale, Ill. He received his bachelor of science degree in electrical engineering from Purdue University, and in 1933 began his career with Commonwealth Edison Company as a meter complaint inspector. He became supervising engineer in the Service and Meter Department in 1945 and a year later was made assistant superintendent of the department. Mr. Bushnell was also a member of the Western Society of Engineers and the International Association of Electrical Inspectors.

Robert J. Hare (M '44), staff engineer, Chief Engineers Department, Pacific Telephone and Telegraph Company, Los Angeles, Calif., died on September 12, 1950. He was born in Cincinnati, Ohio, February 17, 1899. Following his graduation from the California Institute of Technology in 1921, with a bachelor of science degree in electrical engineering, he joined the Pacific Telephone and Telegraph Company as an engineer. He spent the intervening 29 years in the service of the company in the Southern California area. Mr. Hare was also a member of the Institute of Radio Engineers.

MEMBERSHIP • • • •

Recommended for Transfer

The board of examiners at its meeting of January 18, 1951, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Fellow

Busch, A. J., director, switching systems div., Bell Telephone Laboratories, Inc., New York, N. Y.
Fawcett, C. D., elec. engg. prof.; private consultant; University of Pennsylvania, Philadelphia, Pa.
Furst, W. A., director, public utilities, City of Gainesville, Fla.
Hills, H. W., engineer, Jackson & Moreland, Boston, Mass.
Hutchinson, C., electrical engineer, Ebasco Services, Inc., New York, N. Y.
Millard, T. O., application engineer, General Electric Co., Chicago, Ill.
Stoppelmann, F. H., engg. switchgear supervisor, Westinghouse Electric Corp., New York, N. Y.
Stroberg, E. A. electrical engineer, Stone & Webster Engineering Corp., Boston, Mass.
Weiss, F. C., vice-pres., Alabama Power Co., Birmingham, Ala.
Whitman, E. B., senior partner, Whitman, Requardt & Associates, Baltimore, Md.

10 to grade of Fellow

To Grade of Member

Boskamp, J. B., supervising electrical engineer, Corps of Engineers, U. S. A., St. Louis, Mo.
Bullen, C. V., professor & head, elec. engg. dept., Texas Technological College, Lubbock, Tex.
Cyrus, H. N., electrical engineer, Ebasco International Corp., New York, N. Y.
Franck, R. E., div. engineer, General Electric Co., West Lynn, Mass.
Halfmann, E. S., engineer, Philadelphia Electric Co., Philadelphia, Pa.
Haynes, H., engineer, lamp dept., General Electric Co., Cleveland, Ohio
Knapp, L. E., central station supervisor, Westinghouse Electric Corp., Cleveland, Ohio
Lee, A. J., engineer, General Electric Co., Schenectady, N. Y.
Martin, E. E., electrical engineer, light div., City of Tacoma, Wash.
McGuire, C. E., supervisor, meter & relay dept., Ottawa Hydro Electric Commission, Ottawa, Ontario, Canada
Pafenbach, W. M., equipment & maintenance engineer, General Electric Co., Pittsfield, Mass.
Stein, W. A., instructor & research engineer, Washington University, St. Louis, Mo.
Turner, J. A., pres., Tampa Armature Works, Inc., Tampa, Fla.
Wagner, R. N., electrical engineer, Aluminum Co. of America, Pittsburgh, Pa.

14 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before March 25, 1951, or May 25, 1951, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Almasi, J., Siena College, Loudonville, N. Y.
Archdeacon, V. J., American Cyanamid Co., Bound Brook, N. J.
Arnold, S. T., Bonneville Power Admin., Portland, Oreg.
Beare, J. W., Century Electric Co., St. Louis, Mo.
Blake, R. W., N. Y. State Elec. & Gas Corp., Binghamton, N. Y.
Boykin, J. R., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Broomell, G. L., Jr., Leeds & Northrup Co., Philadelphia, Pa.
Brown, A. P., Westinghouse Elec. Corp., Nashville, Tenn.
Centre, I. M., 4119 MacGregor Dr., Columbia, S. C.
Clark, C. M., British Columbia Telephone Co., Vancouver, B. C., Canada
Collier, C. S., E. I. du Pont de Nemours & Co., Wilmington, Del.
Crompton, C. W., Pennsylvania Power & Light Co., Harrisburg, Pa.
Dugdale, T. W., Indiana & Michigan Elec. Co., South Bend, Ind.
Edwards, T. H., General Elec. Co., Richland, Wash.
Erith, H. A., Shawinigan Engineering Co., Montreal, Quebec, Canada
Ferguson, J. C., Capehart-Farnsworth Corp., Ft. Wayne, Ind.
Godshalk, J. B., Fox Products Co., Philadelphia, Pa.
Gorrill, W. S., Hanson-Gorrill-Brian, Inc., Glen Cove, N. Y.
Greenefege, S., Copperweld Steel Co., New York, N. Y.
Hood, H. E., Valley Radio Supply, Bakersfield, Calif.
Hutchins, L. H., Jr., Simplex Wire & Cable Co., Cambridge, Mass.
Mace, J. M., Northern Elec. Co., Ltd., Montreal, Quebec, Canada
Manson, C. A., British Columbia Electric Railway Co., Ltd., Vancouver, B. C., Canada
Mayo, H. C., The M. W. Kellogg Co., New York, N. Y.
Miller, R. G., Westinghouse Elec. Corp., Los Angeles, Calif.
Nichols, N. B., University of Minnesota, Minneapolis, Minn.
Norman, W. E., Edenfield Elect. Inc., Oak Ridge, Tenn.
Pare, E. R., Board of Examiners of Electricians, Provincial Govt., Montreal, Quebec, Canada
Preacher, G. H., 1226 Bull St., Columbia, S. C.
Robinson, W. G., Sverdrup & Parcel, Inc., St. Louis, Mo.
Runyeon, G. M., Acro Mfg. Co., Columbus, Ohio
Schramm, M. C., General Elec. Co., Schenectady, N. Y.
Seheult, K. F., Trinidad & Tobago Elec. Comm., Port-of-Spain, Trinidad, B. W. I.
Shafer, A. J., Wisconsin Power & Light Co., Madison, Wis.
Smith, S. V., The Pennsylvania Railroad, Philadelphia, Pa.
Soutar, F. J., Austin Co. at Dow Chemical Co., Velasco, Tex.
Stang, W. H., Pennsylvania Power & Light Co., Allentown, Pa.
Thomson, H. W., U. S. Bureau of Reclamation, Elverta, Calif.
Troischt, E. M., General Elec. Co., Philadelphia, Pa.
Verma, B. P., Government of India, M.E.S., Allahabad, New Cantt., U.P., India
Watts, C. U. (Mrs.), The Western Union Telegraph Co., New York, N. Y.
White, H. R. C., South Western Electricity Board, Penzance, Cornwall, England
Wiggans, L. E., California-Pacific Utilities Co., Baker, Oreg.

43 to grade of Member

OF CURRENT INTERES

Power Compressors Provide Continuous Operation in Hypersonic Wind Tunnel

Speeds of more than ten times the velocity of sound are being obtained in the recently completed hypersonic wind tunnel on the campus at the California Institute of Technology, Pasadena, Calif. Powered principally by General Electric motors, the tunnel was designed and built for the Institute and the Army Ordnance Department to provide vitally needed information for use in the design of future missiles at speeds well above those of present-day rockets and missiles.

The new tunnel, called "hypersonic" because of the terrific air speeds attained, has been operated at higher than Mach 10. (A Mach number of 1 represents a speed equal to the speed of sound which is approximately 760 miles per hour at sea level.) The Ordnance—California Technology tunnel operates continuously during experiments, and air velocities of Mach 10 can be obtained for any length of time desired.

The test section, in which models are mounted, is only 5 by 5 inches, although the entire tunnel has an over-all length of four feet. This includes a region of acceleration downstream from the nozzle throat, the test section, and the diffuser section, where the process of slowing down the air takes place.

To accelerate in the expansion section, the air must pass through a slot in the throat of a specially designed steel alloy nozzle. The height of the slot depends on the Mach number desired. Thus, at a speed of Mach 10, air at tremendous pressure blasts through a tiny slit less than 0.005 inch high, or approximately the thickness of a sheet of paper. When the air suddenly expands into the test section, the temperature drops to about 430 degrees below zero Fahrenheit, while the pressure drops to about one millimeter of mercury, or 0.001 normal atmospheric pressure.

Air, at pressures as high as 1,000 pounds per square inch, is provided by rotary-vane type and double-acting reciprocating-type compressors. The piping arrangement of the compressors can be varied by a system of valves to provide series or parallel compression.

The compressor room, located in the basement immediately below the tunnel, also houses the General Electric motors which drive the compressors. Two 150-horsepower 600-revolutions-per-minute motors drive eight rotary compressors, four in tandem to each motor. One 200-horsepower 600-revolutions-per-minute motor and one 75-horsepower 600-revolutions-per-minute motor each drive two more rotary compressors mounted in tandem. Two 100-horsepower 1,180-revolutions-per-minute induction motors are belt-connected to drive the remaining two compressors.

Four of the 1,000-horsepower compressor motors which provide power for the new hypersonic wind tunnel at the California Institute of Technology, Pasadena, Calif.

Signal Corps Camera Produces Quick, Radiation-Proof Picture

Development of a new type camera usi invisible electrical images which can produ on-the-spot pictures even in active aton radiation areas without being fogged h been sponsored by the Signal Corps En neering Laboratories, Washington, D. C.

A model of the camera, dubbed "Tw Minute Minnie," produces a finished 4-b 5-inch picture two minutes after the shutt is snapped. Its plates, which need chemicals for processing, can be used ov and over again merely by wiping off t image.

The picture has tones similar to that an ordinary black and white photogra and can be printed on paper, wood, clot glass, plastics, or ceramic materials. can be made into a transparency from whi enlargements can be produced.

The camera employs the newly discover electrostatic, electrophotographic process which light is recorded on a selenium-coat metal plate that has been sensitized by electric charge. Where the light hits t charged plate, the electricity leaks off t sensitized material in proportion to t amount of light received and is grounded the plate. What is left is an invisible ele trical image.

Finely ground charcoal or anthracite co powder then is blown across the face of t plate. Wherever there is electricity on t plate the dust sticks—the more the electricit the more powder remains. The powdere image then is transferred to ordinary pap or other material coated with an adhesiv layer, such as rubber cement. To prote the surface and fix the print, a clear tran parent plastic film is pressed against t picture.

For military use, the new camera, when reaches the field, will offer several advantag over the conventional silver process photography:

1. Need for a darkroom in the field wi be eliminated. The entire process is done i the back of the camera within two minute It is predicted that this time will be cut to minute or less within a year.
2. Storage problems in the field will b lessened. The plates are not sensitive light until electrically charged in the bac of the camera. Also, a small supply plates can be used over and over again.
3. The plates are not affected or fogge by atomic radiations. Ordinary film is.

The camera uses an ordinary lens an shutter. Its light source is the same as fo an ordinary camera—sun or reflected ligh photofloods, flash bulbs, or ordinary lig bulbs. The speed of the sensitive plate about the same as the ordinary orthochr matic black-and-white film.

Development of the camera was und sponsorship of the Signal Corps which aide the Haloid Company, Rochester, N. Y., an the Battelle Memorial Institute, Columbu Ohio, in the research and design leading production of a model.

ew Storage Battery Developed by Bell Telephone Laboratories

A new, long-life storage battery, requiring
ıch less maintenance and lasting at least
lf again as long as those now in use, has
en developed by Bell Telephone Labora-
ries' scientists for use in telephone central
ices throughout the nation.

The battery was developed for the specific
quirements of the telephone industry.
present, it is not recommended for other
es. As more information about its charac-
istics is obtained, its field of usefulness
ay be extended considerably.

The new battery, which is less subject to
rrosion, has the further advantage of serv-
g for many months without the addition of
ater. And it loses only four per cent of
total charge each month—one-fifth of the
nount lost by present storage batteries.

Since it does not often have to be replaced and requires so little maintenance, the battery is expected to reduce considerably the cost of providing stand-by power for the nation's telephone network. In the Bell system alone there are a million storage battery cells connected to telephone circuits. In the rare event of power failure, these batteries are ready to supply the vital current for telephone service.

By changing a single ingredient, the clue to which came unexpectedly from another line of research, the Bell scientists expect to achieve a saving of more than a million dollars a year. Production of the new batteries already has been started. As they become available, they will gradually replace the present type of battery.

A minute trace of an unusual gas in a telephone office started the Laboratories' chemists on the road to their discovery. They were searching for atmospheric impurities which they suspected might be tarnishing parts of the elaborate switching mechanism used in the dial system. They carried their investigation to all parts of the telephone central office, eventually setting up their experiments in the battery rooms. Here they detected in the atmosphere, during the overcharge period, a gas having a very different test reaction from any they had found elsewhere. Uncertain at first of its identity, they returned to the Laboratories, set up some storage batteries, overcharged them and collected enough of the unknown gas by freezing it out in a liquid air trap. The frozen gas looked like a small pile of snow, and on analysis it proved to be antimony hydride, commonly known as stibine. It was not stibine which was causing the tarnishing of equipment, but detecting its presence gave the chemists an important clue to some peculiar actions within the batteries.

After exhaustive research they found that antimony, a metal commonly used to harden lead, was passing undetected from one plate to another within the cell, and was speeding up corrosion and causing an electrochemical action which resulted in partial discharge of the negative plate. In this process, the by-product, stibine gas, was being produced. It seemed clear, then, that if they could eliminate the antimony a better battery would result.

They learned that in experimenting with hardening agents for the lead covering of cables, metallurgists had successfully used small amounts of calcium instead of the usual antimony. Less than one-tenth of one per cent of calcium, compared with the 12 per cent of antimony usually employed in battery alloy, could do the job. And the battery chemists found, too, that calcium does not cause any of the troubles for which antimony had been responsible.

From here it was only a brief step to development of the new, lead-calcium storage battery, although it has taken several years to prove its suitability and endurance.

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uture Meetings of Other Societies

nerican Material Handling Society. Materials
ındling Conference held concurrently with the Na-
nal Materials Handling Exposition. April 30–May
1951, International Amphitheatre, Chicago, Ill.

nerican Society for Testing Materials. Spring
eeting. March 5–9, 1951, Cincinnati, Ohio.

nerican Society of Mechanical Engineers. Spring
eeting. April 2–5, 1951, Atlanta Biltmore Hotel,
lanta, Ga.

nerican Society of Tool Engineers. 19th Annual
eeting. March 14–17, 1951, Hotel New Yorker,
w York, N. Y.

**sociation for Computing Machinery and Industrial
thematics Society.** Joint Meeting. March 27–28,
51, Wayne University, Detroit, Mich.

nference on Industrial Personnel. March 19–23,
51, Columbia University, New York, N. Y.

**urth Annual Conference for Protective Relay
gineers.** March 26–28, 1951, Agricultural and
chanical College of Texas, College Station, Tex.

draulic Institute. March 5–7, 1951. Santa Bar-
a Biltmore Hotel, Santa Barbara, Calif.

minating Engineering Society. Southwestern
eting. March 4–6, 1951, Driscoll Hotel, Corpus
risti, Tex.

titute of Radio Engineers. Annual Convention.
rch 19–22, 1951, Waldorf Astoria Hotel and Grand
ntral Palace, New York, N. Y.

titute of Radio Engineers. Southwestern Con-
nce. April 20–21, 1951, Southern Methodist
iversity, Dallas, Tex.

trument Society of America. Conference being
d by the Pittsburgh Section and the Carnegie In-
ute of Technology. March 28–29, 1951. Pitts-
gh, Pa.

dwest Power Conference. 14th Annual Con-
nce. April 4–6, 1951, Sherman Hotel, Chicago,

ional Association of Corrosion Engineers. March
16, 1951, Hotel Statler, New York, N. Y.

ional Electrical Manufacturers Association.
rch 12–15, 1951, Edgewater Beach Hotel, Chicago,

nsylvania Electric Association. Prime Movers
nmittee. March 8–9, 1951, Berkshire Hotel,
ding, Pa.

iety of Motion Picture and Television Engineers.
ing Convention. April 30–May 4, 1951, Hotel
tler, New York, N. Y.

iety of the Plastics Industry. Sixth Annual Tech-
al Session. February 28 and March 1–2, 1951,
ewater Beach Hotel, Chicago, Ill.

iety of Women Engineers. Third Annual Con-
nce. March 10–11, 1951. Hotel Barbizon for
men, New York, N. Y.

The ECPD and What It Means to the Engineering Profession

The Engineers' Council for Professional Development (ECPD) is a conference body that is sponsored and supported financially by the major engineering societies. Its responsibility is the professional progress of the individual engineer regardless of his specialized technical field.

The governing body of ECPD is a Council composed of 24 voting members, three from each sponsoring organization and seven ex officio members who represent the ECPD standing committees. The Council has two main functions: it explores fields of professional engineering development and works to secure the adoption of programs to the end that the obligations of its charter may be met.

The Council now has seven standing committees. Five of these cover all stages of professional growth of the individual: guidance, education, student development, training, and recognition. Two other committees deal with the question of ethics and information. In addition, there is a special committee on Unity of the Engineering Profession.

One of the basic ECPD concepts is that there are four normal stages in the life of the engineer, in each of which the engineering profession has a responsiblity. In the first or precollege stage, the profession must see that only those who are fully qualified should embark on the course of engineering studies. In the second stage, that of undergraduate study, the profession must share with the colleges the responsibility for standards of engineering instruction. In the third stage, which begins when the young engineer enters practise, the profession must create the opportunities for further personal and professional growth; and in the fourth stage of full professional practise the profession must concern itself with the legal and professional standards by which the engineer becomes established and recognized.

The ECPD was organized on October 3, 1932, and immediately began its work of promoting the welfare of individual engineers. Of the achievements of ECPD, the best known is the work of its Committee on Engineering Schools, which as of October, 1949, has examined and accredited 734 engineering curricula in 146 engineering schools of the country. Also well known is the establishment of the "Canons of Ethics for Engineers," which have been adopted by all eight of the participating bodies of the Council. Altogether, 65 engineering societies in the United States and Canada have adopted the Canons.

ECPD is supported financially by grants from its eight constituent engineering organizations, which are American Society of Civil Engineers; American Institute of Mining and Metallurgical Engineers; American Society of Mechanical Engineers; AIEE; Engineering Institute of Canada; American Society for Engineering Education; American Institute of Chemical Engineers; and National Council of State Boards of Engineering Examiners. Its main work is accomplished by 350 practising engineers and educators who give their time freely toward the major objectives of the organization, namely: "to co-ordinate and promote efforts to attain higher professional standards of education and practise, greater solidarity of the engineering profession, and greater effectiveness in dealing with technical, economic and social problems."

Any information desired concerning the ECPD can be obtained from the office of the Engineers' Council for Professional Development, 29–33 West 39th Street, New York, N. Y.

National Standards of Weights and Measures Maintained by NBS

This year marks the bicentennial of the National Bureau of Standards (NBS) which, as the custodian of the national standards of physical measurement, not only sets up and maintains the basic standards of length, mass, time, and other physical quantities, but also undertakes the necessary research leading to improvements and refinements in such standards and measurement methods. At the same time, the NBS constructs, maintains, and intercompares reference and working standards which are calibrated in terms of the national standards and used in science, engineering, and industry.

In 1901, in response to the growing need for a national scientific laboratory and in recognition of the standards that had been established in weights and measures (the Constitution states that Congress has the power "to fix the standard of weights and measures"), the Congress enacted a law establishing the National Bureau of Standards. One of the most interesting of the Bureau's many studies is that of the standard of mass, the uniformity of which is necessary to maintain high accuracy in scientific weighing as well as being of great economic importance to the producing, manufacturing, processing, and distributing agencies of this country and to all purchasers of commodities.

The national standard of mass—a platinum-iridium cylinder about $1^1/_2$ inches high, $1^1/_2$ inches in diameter, and having a mass of almost exactly one kilogram—is maintained in a special vault of the NBS. The United States standard kilogram, like the standard meter bar, is a copy of an international standard kept at the International Bureau of Weights and Measures at Sèvres, France. It is known as Prototype Kilogram Number 20, and was established as the national standard by executive order in 1893. Since that time the pound and other everyday units of mass have been defined by the ratio of their mass to the mass of this kilogram.

Weights and weighing devices employed by other Federal agencies, such as the weights used by the Bureau of Internal Revenue to weigh the products of distilleries or those used by the Customs Bureau to weigh cargoes, are tested and calibrated directly by the NBS. Thus, through the introduction of the metric carat, based on the standard kilogram, uniformity in the measurement of the weight of gems has been achieved. Likewise, uniformity in the manufacture of drugs is now possible through the use of certified weights. In accordance with an Act of Congress in 1911, the weight and fineness of coinage is verified each year through comparison with standard weights of the NBS.

The services of the Bureau are performed for agencies of the Federal and State governments, scientific societies, educational institutions, and firms or individuals within the United States engaged in manufacturing or other pursuits requiring the use of standards or standard measuring instruments.

$100,000 Engineering Man Power Project Launched by EJC

Plans for a $100,000 campaign to inform the public of the importance of the engineering function and to insure more effective use of engineers in industry, construction, and the Armed Forces were approved by the Engineers Joint Council (EJC) at a meeting held in the Engineering Societies Building, New York, N. Y., January 19, 1951. James M. Todd, president of EJC, presided.

The plan will be administered by the 20-man EJC Engineering Man Power Commission and will be supported by funds solicited from employers of engineers in business, industry, and in public and private construction. In the same action EJC asked The American Society of Mechanical Engineers (ASME) to assign its secretary, C. E. Davies, to the job of director of the EJC Engineering Man Power Commission.

The three main objectives of the EJC Engineering Man Power Commission, according to formal plans approved by the Council, will be: (1) to overcome future shortages of engineering graduates by increasing enrollments in engineering schools (2) to assure better utilization of presen engineering man power by alerting employer of engineers to the need for better utilization caused by the impending shortage and (3) to act as consultant to governmenta bodies in order to assist in conservation o engineering man power.

Plans for expanding the Commission cal for an executive committee composed of chairman and a Commission member from each participating society; an editoria committee composed of seven members each of whom is experienced in some phas of the man power project; and a development committee of six members whos function will be to raise necessary funds t carry on the program.

E. G. Bailey, temporary chairman of th EJC Commission, said that the Commission has placed itself at the disposal of the Scientific Man Power Advisory Committee of th National Security Resources Board headed by Charles A. Thomas, Vice-President Monsanto Chemical Company. The Thomas Committee has called upon the EJC Commission for information in two instances On December 29, 1950, the Committee asked EJC to find how many engineers and scientists were enrolled with the Armed Services Reserves. The following day the EJC sent a telegram to 95 companies asking for data On January 4, the EJC was able to advise the Thomas Committee that based on a 10 per cent sampling of American engineers, 25 per cent of the engineers employed by 5 representative employers of engineers were enrolled in the active reserves. The Commission, Mr. Bailey added, is currently collecting data for the Thomas Committee on availability of technicians, toolmakers, glassblowers, machinists, and other supporting personnel essential to the work o engineers.

Working Committees of the EJC National Water Policy Panel are being reactivated to study the 445-page report recently made public by the President's Water Resources Policy Commission headed by Morris L Cooke, consulting engineer, Philadelphia, Pa. This was announced in a progress report by W. W. Horner, Chairman of the EJC Panel.

The standard test weight car, owned and operated by the NBS, is used for calibrating and adjusting the master railway track scales of the nation's railroads. A test load of 80,000 pounds is carried by the car. With the small balance of high precision (shown at right) the NBS compares standard weights for microbalances with the standards of mass maintained at the Bureau ach Committee plans to compare by xtaposition its own recommendations pub- shed in the 250-page EJC report on national ater policy (*EE, May '50, p 478*) with ose of the Cooke Commission.

Legislation incorporating recommenda- ons of the President's Commission will be shape for Congressional consideration in vo months, Mr. Horner estimated. The JC Panel is working to prepare a statement pplementing its first report which will rovide legislators and other persons in- rested in water policy with point-by-point omment on recommendations of the Cooke ommission.

Continued progress by the Exploratory roup on Unity of the Engineering Pro- ssion was reported by H. S. Osborne, airman of the EJC delegation to the xploratory Group. Meeting on December , 1950, the Group approved a document repared by its working committee in which ur plans for engineering unity are proposed d discussed by various members of the 15- ciety group. The report is to be circulated mong the sections and chapters of EJC cieties for eventual agreement on a single an.

Upon recommendation of its Commission Latin America, EJC agreed to send dele- tes to the Havana Conference of UPADI nion of Pan American Societies of Engi- ers), April 19–22, 1951, the delegation to made up of one representative from each nstituent society.

estinghouse Fellowship Available for 1951–52

The Westinghouse Educational Founda- on has established a graduate fellowship power systems engineering at Illinois stitute of Technology to train men of perior ability for advanced work in central ation engineering. The fellowship provides r three semesters of intensive training and ads to the degree of master of science in ectrical engineering from Illinois Institute Technology.

The award considers personal qualifica- ns, interests, and scholarship. Candidates ould have a bachelor's degree in electrical gineering from an accredited engineering hool. The stipend is $1,500 ($500 plus ition each semester for three semesters). he appointment will be effective September , 1951. Applications must be received March 15, 1951, and decision will be nounced to all applicants by April 1, 1951. rms may be obtained from Office of Ad- issions, Graduate School, Illinois Institute Technology, Technology Center, Chicago , Ill.

roceedings of 13th Biennial Session of CIGRE Available

The Paris Headquarters of CIGRE (Inter- tional Conference on Large Electric igh-Tension Systems) has announced that e printed Proceedings of the 13th Biennial ssion of CIGRE which was held in Paris, ne 29 to July 8, 1950, and was attended by 577 delegates from 42 different countries, e now ready for distribution.

The Proceedings, consisting of three cloth-bound volumes totalling 3,248 pages, are available in either English or French and contain all of the 126 technical papers presented at the 1950 Session, revealing the latest developments in electric equipment and apparatus and in operating practices on high-tension electric systems in 20 different countries. It also includes the full discussions of these papers by delegates from all countries and all of the International Study Committees' reports, as well as other special technical reports summarizing the work of the various sections into which CIGRE activities are divided.

CIGRE activities embrace all problems relating to the production, transmission, and distribution of electric energy and to the design and operation of associated electric equipment and apparatus. Consequently, these Proceedings provide a valuable source of reference to all operating and manufacturing engineers and executives in the electric power industry and to all technical schools, libraries, and associations.

The delivered price of the 3-volume set of the 1950 CIGRE Proceedings is 9,000 francs ($25.71) to nonmembers of CIGRE and 7,500 francs ($21.43) to CIGRE members. Subscriptions may be mailed with remittances in either French or United States currency to:

CIGRE
112 Boulevard Haussmann
Paris, France

Further information relating to CIGRE activities or the 1950 Proceedings may be obtained from:

Frederic Attwood, Chairman
U. S. National Committee of CIGRE
Room 1781, 50 Church Street
New York 7, N. Y.

Bibliographies Issued by Engineering Societies Library

The series of bibliographies on subjects of general interest, compiled by the staff of the Library, have been so helpful to many engineers that the complete list is now being given here for those who may not have seen earlier announcements.

Bibliography Number 1. Filing Systems for Engineering Offices. 41 references. 1948. $2.00.
Bibliography Number 2. Prestressed Reinforced Concrete. 190 references. 1948. $4.00.
Bibliography Number 3. Precision Investment Casting by the Lost Wax Process. 111 references. 1949. $2.50.
Bibliography Number 4. Pallets Used in Modern Materials Handling. 114 references. 1949. $2.00.
Bibliography Number 5. Machinery Foundations; Design, Construction, Vibration Elimination. 120 references. 1950. $2.00.
Bibliography Number 6. Non-Metallic Bearings. 101 references. 1950. $2.00.
Bibliography Number 7. Domestic and Industrial Applications of Solar Heating. Approximately 150 references. 1950. $2.00.
Bibliography Number 8. Management of Construction Jobs. *In preparation.*

Percy Good, Director of British Standards Institution, Dies

Percy Good, internationally known standardization executive and electrical engineer and Director of the British Standards Institution, died on December 2, 1950. Mr. Good, a past member of the AIEE, was born in London, England, on November 5, 1880. He became associated with the British Standards Institution in 1913 as assistant director. He was made deputy director in 1929 and Director in 1942. It was soon after Mr. Good became director that the international conferences were held which later resulted in the British-American Canadian Unified Screw Thread.

Mr. Good had an intense interest in the international aspects of standardization. He was an important figure in the work that led to the International Organization for Standardization.

In addition to his stature as a standardization executive, he had an international reputation as an electrical engineer. For many years he was secretary of the British National Committee of the International Electrotechnical Commission and was well known in electrical circles in the United States for his work with that group. His high reputation in this field was recognized in his election as President of the British Institution of Electrical Engineers in 1947. He also served as President of the British Illuminating Engineering Society.

Journal of Franklin Institute Commemorates 125th Year

Fifteen papers written on expected scientific developments by the leading authorities in several fields of science and technology constitute a symposium, "Science . . . and Tomorrow," appearing in the January issue of the *Journal* of The Franklin Institute.

Commemorating its 125th year, this issue of the *Journal* is intended to predict future developments in science and technology based upon the considered opinions of today's leading authorities. It is a composite picture of what can reasonably be expected in the basic physical and applied sciences.

First published by The Franklin Institute in 1826 "to diffuse information on every subject connected with useful arts," the *Journal* in this anniversary issue retains the character with which it was first started. However, there is one principal difference. The earlier contributors were intent upon keeping a record of what had already been accomplished, while the group of eminent scientists who have contributed to this latest issue have kept their eyes on the future. Their work in the current *Journal* is of a nature that foreshadows ultimate development.

Oak Ridge School of Reactor Technology. This school has been set up under the sponsorship of the United States Atomic Energy Commission to train engineers and scientists in the field of reactor theory and technology (*EE, Feb '51, p 179*). The receipt of applications for enrollment has been extended from March 1, 1951, to April 1, 1951.

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

CIRCUIT ANALYSIS OF A-C POWER SYSTEMS, Volume II. By E. Clarke. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1950. 396 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, linen, $8.50. Continuing the treatment started in Volume I, this book presents methods for determining the performance of a-c power systems under normal and abnormal operating conditions. The electrical characteristics of insulated cables, various types of transformers and autotransformers, synchronous machines, and induction motors are determined, with special attention to the development of equivalent circuits for use in the component networks. As in Volume I, circuits are analyzed by means of components.

COLLOIDAL DISPERSIONS. By E. K. Fischer. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1950. 387 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, linen, $7.50. This monograph serves as a guide to the theory and practice of the dispersion of solids in liquid media. The first five chapters supply the theoretical background for much of the work done in industrial laboratories. The remaining chapters are devoted to manufacturing details involved in the production of colloidal dispersions, including the efficient operation of mills and dispersion equipment.

ECONOMIC ASPECTS OF ATOMIC POWER, an Exploratory Study under the Direction of S. H. Schurr and J. Marschak. Published for the Cowles Commission for Research in Economics by Princeton University Press, Princeton, N. J., 1950. 289 pages, charts, tables, maps, 10¼ by 6¾ inches, linen, $6.00. This book is an exploratory study of the economic effects which would be produced by the use of atomic power for the production of electricity or heat. It begins with questions on the technical feasibility and economics of atomic power. The cost then is compared, for various areas of the world, with the cost of electricity from conventional sources. This analysis is followed by a study of the potential applicability of atomic power in selected industries. It concludes with a parallel study on national and regional economies and on the industrialization of so-called backward areas.

ECONOMICS OF AMERICAN INDUSTRY. By E. B. Alderfer and H. E. Michl. Second edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 716 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, linen, $5.50. Revised and brought up to date, this second edition reflects the technological and structural changes which have taken place since the first edition was published in 1942. Industries included are: metal and metal fabricating, nonmetallic minerals, chemicals, petroleum, rubber, textiles, apparel, food, and so forth. For each industry, the latest available data are provided to indicate changes in productive capacity, shifts in location, development of new industrial areas, and additional manufacturing facilities.

PLANT ENGINEERING HANDBOOK. Edited by W. Staniar. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 2,007 pages, diagrams, charts, tables, 9¼ by 6 inches, cloth, $15.00. Prepared by a staff of specialists, this comprehensive new reference work covers the essentials of good practice in the economic, mechanical, chemical, and power areas of modern industrial plant operation. Topics covered include: industrial costs and management; plant construction and maintenance; fire prevention; water treatment; power plants and refrigeration; instrumentation and control; mechanical and hydraulic power systems; bearings and lubrication; materials handling and conveying; and a wide range of basic processes, materials, problems, and miscellaneous information. A detailed 50-page index is provided.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

PROCEDURE HANDBOOK OF ARC WELDING DESIGN AND PRACTICE. Ninth edition. Lincoln Electric Company, Cleveland, Ohio, 1950. 1,200 pages, illustrations, diagrams, charts, tables, 8¾ by 5⅜ inches, fabrikoid, $2.00 in United States; $2.50 foreign. In the ninth edition, the data have been reorganized and consolidated to retain all currently useful material from the previous edition and to include new material. The main section headings are: arc-welding history, processes, equipment, and nomenclature; weldability of metals; techniques, procedures, speeds, and costs for welding mild steel; basic design data for welded construction; machinery design with arc-welded construction; designing of arc-welded structures; inspection and testing of weld metal and welding operators; and miscellaneous applications of arc welding in manufacture, construction, and maintenance.

TRANSMISSION LINES AND NETWORKS. By W. C. Johnson. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 361 pages, diagrams, charts, tables, 9¼ by 6¼ inches, fabrikoid, $5.00. A unified treatment of the theory of transmission lines and 4-terminal networks, with applications to both the power and communication fields. Following a general survey of theory of transmission lines, special considerations relating to the separate fields of power transmission, telephone and telegraph transmission, and radio-frequency transmission lines are discussed. The theory of networks is similarly treated with applications to attenuations, impedance-matching networks, and filters. A knowledge of integral calculus and elementary a-c circuit theory is assumed. Both theoretical and practical problems are provided at the end of almost every chapter.

WAVE MOTION AND SOUND. By R. W. B Stephens and A. E. Bate. Longmans, Green and Company, New York, N. Y.; Edward Arnold & Company, London, England, 1950. 448 pages, illustrations, diagrams, charts, tables, 8¾ by 5¾ inches, cloth, $9.00. Following a historical introduction, fundamentals such as periodic motion, wave propagation, transverse vibrations, reflection, refraction, and interference, are discussed. The velocity of sound, resonance, and wave analysis are next considered. The later chapters deal with special topics: music; acoustical measurements; architectural acoustics; ultrasonics; and electrical, mechanical, and acoustical analogies. By the inclusion of an extensive mathematical appendix, the book is designed to fill the gap between the elementary textbook and the advanced treatise.

STEAM-PLANT OPERATION. By E. B. Woodruff and H. B. Lammers. Second edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 543 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, cloth, $7.00 This book is designed to assist the practical man in securing a working knowledge of the fundamental principles of stationary engineering. In this second edition, new material brings both the description of equipment and the techniques of operation and maintenance up to date. Important changes include new information on welded-boiler construction; fuel-oil and spreader stokers; technique in the operation and maintenance of boilers, engines, turbines and auxiliaries; and fuel economy. Questions and problems with answers are included at the end of each chapter.

TV AND OTHER RECEIVING ANTENNAS (Theory and Practice). By A. B. Bailey. John F. Rider Publisher, 480 Canal Street, New York 13, N. Y., 1950. 595 pages, diagrams, charts, tables, 8½ by 5½ inches, cloth, $6.00. Of value both to the student and to the communications engineer, this practical book begins with a review of definitions and terminology, an analysis of the television signal, and discussion of the conditions that determine signal levels at the receiver. Succeeding chapters take up in turn the major types of receiving antennas, including discussion of their advantages and disadvantages and practical suggestions as to which are best for certain areas. Condensed data sheets are included for approximately 50 different antenna types.

PAMPHLETS • • • •

The following recently issued pamphlets may be interest to readers of "Electrical Engineering." A inquiries should be addressed to the issuers.

Safety in Electric and Gas Welding an Cutting Operations. This standard cover regulations for the safe installation an operation of welding equipment for all arc gas, and resistance welding processes. Pro visions are included for fire prevention an protection in regularly assigned weldin areas and in other locations as well. Th protection of personnel is covered from th standpoint of the welder, for whom ey protection and clothing requirements, healt protection, and so forth, are prescribed, an from the standpoint of other workers i areas adjacent to welding operations. Copie are available at 50 cents each from th American Welding Society, 33 West 3 Street, New York, N. Y.

Home Wiring Handbook. This is the thir edition of the Home Wiring Handbook, 135-page guide for planned wiring of home in the popular-priced group. Because th average annual energy consumption 1,700 kilowatt hours per residential custome is increasing, home wiring needs an engineer ing approach. Wiring should be safe an efficient but, in addition, it should provid flexibility that can match progress made o utilization of electric equipment. The gui is available at $1.00 each from Westinghous Electric Corporation, P. O. Box 209 Pittsburgh 30, Pa.

New Bulletin on Inspection and Wor Light. This 2-page illustrated bulleti shows three sizes of the lights, an applicatio photo, and the parts in detail. This portabl fluorescent light is dust-tight, moistur tight, and is widely used in the aircraf automotive, shipbuilding, and petroleu industries. Other valuable uses have bee found in industrial plants for hard-to-reac machinery inspection and repair, in boile and bottling works, for storage tanks, unde water repair and salvage, and for gener household, farm use, and garage mai tenance. Light and Inspection Bulleti Number Four available upon request fro Commercial Reflector, 3111 Maple Avenu Los Angeles 11, Calif.

American Standard Test Code for App ratus Noise Measurement. This standa establishes uniform methods of conducti and recording sound-level tests on apparat It is intended as a guide for those who u sound-level meters that meet the requir ments of the American Standard Soun Level Meters for Measurement of Noise an Other Sounds. The standard includes pr cedures for factory tests of equipment, fie investigations, and sound-level specificatio The section devoted to factory tests contai methods for measurement of direct ai borne noise; reflected sound; ambie sound; apparatus mounting; location microphone; standing waves; record measurements; and noise measuremen Copies available from the American Stan ards Association, 70 East 45 Street, Ne York 17, N. Y., at 50 cents a copy; ask Standard Number *Z.24.7–1950.*

"Superior Performance" says LOUIS ALLIS about the new VICKERS Magnetic Amplifier Control on their new *Adjustable Speed Drive*

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INDUSTRIAL NOTES . . . .

Condenser Products Moves to New Factory After Fire. Shortly after a fire destroyed most of their factory and equipment at midnight on January 10, Condenser Products Company, Chicago, Ill., signed a lease for new and much larger quarters at 7517 North Clark Street. The office and engineering records were left intact, and the company expects to recommence manufacturing in the early part of February.

Westinghouse Expansion Planned. The Westinghouse Electric Corporation has announced: plans to build a new plant for the production of small electric motors in Union City, Ind., with Ralph E. Davis in charge; formation of an Electronic Tube Division, with plans for three new plants to manufacture various types of tubes (E. W. Ritter has been named manager of this new division); the opening of a new micarta plastics plant in Hampton, S. C.; the purchase of plant number 1 of the Pharis Tire and Rubber Company at Newark, Ohio, for conversion to a feeder operation for the Westinghouse main appliance division plant at Mansfield, Ohio; and plans for two new East Pittsburgh buildings of the Westinghouse Electric Corporation that will increase by 65 per cent the capacity to produce giant electric generators. These new structures will make possible the construction of larger than 150,000-kw high-speed 3,600-rpm generators. Three old buildings, one of them the Meter Works building on Braddock Avenue, are being razed to provide room for the new buildings.

The Corporation has also announced the appointment of Dr. Daniel Alpert as manager of the Physics Department of the Westinghouse Research Laboratories. Dr. Alpert succeeds the late Dr. R. C. Mason.

Kerite Appointment. Franklin S. Harris, formerly manager of The Kerite Company's Seymour, Conn., plant, has been appointed a company Vice-President.

Line Material to Build Million Dollar Plant. The Line Material Company, Milwaukee, Wis., has announced plans for a million dollar electrical distribution equipment plant at Sharman, Tex.

RCA News. Ernest B. Gorin, Treasurer of the Radio Corporation of America, has been elected a Director of RCA Communications, Inc., and Emanuel Sacks has been named Staff Vice-President of the Radio Corporation of America.

F. A. Rose Joins Porcelain Products. Frederick A. Rose has joined Porcelain Products, Inc., at their Parkersburg, W. Va. plant as manager of manufacturing.

(*Continued on page 26A*)

EXPERIENCE?

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AMPERE RATINGS	1200	to	7000 Amperes
VOLTAGE RATINGS	5000	to	69,000 Volts
INSTALLATIONS	72, over 100,000 KVA: Generators, Transformers, Distribution Buses, Main Buses		213

PLANT INVESTMENT

SINGLE PHASE FOOTAGE

Write for I-T-E Catalog 10147 for complete information on uses, construction and installation of I-T-E Isolated Phase Bus Structures, as well as convenient data and suggestions for planning a bus layout. Or ask your local I-T-E representative for information. He will be glad to help you.

ISOLATED PHASE BUS STRUCTURES

I-T-E Circuit Breaker Company, 19th and Hamilton Streets, Philadelphia 30, Pa.

Power Switching Equipment: Railway and Industrial Engineering Co., Greensburg, Pa.

Canadian Mfg. & Sales: Eastern Power Devices, Ltd., Toronto • Export Sales: Philips Export Corp., New York

SWITCHGEAR • UNIT SUBSTATIONS • ISOLATED PHASE BUS STRUCTURES • CIRCUIT BREAKERS • MECHANICAL RECTIFIERS • RESISTORS • SPECIAL PRODUCTS

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NEW CLASS H*
MOTORS PROTECTED BY
DOW CORNING SILICONES

. . . the insulation that has already saved industry millions of maintenance dollars plus the hourly output of hundreds of thousands of men!

This most timely announcement caps the test program we started 8 years ago when silicone resins were introduced by Dow Corning Corporation. First we proved by accelerated life testing that silicone insulated motors had a good 10 to 1 advantage in life expectancy and wet insulation resistance. Then we sold silicone (Class H) insulation to the manufacturers of electrical equipment ranging from lift truck and traction motors to solenoid and brake coils. We also encouraged the better rewind shops to rebuild hard working industrial motors with Class H insulation.

Now we can proudly refer American industry to this goodly list of electrical manufacturers, all able and willing to supply electric machines protected by Class H insulation made with Dow Corning Silicones.

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* "Class H" insulation is the kind of insulation that keeps motors running in spite of "Hell and High water." (slanguage dictionary)

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MIDLAND, MICHIGAN
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(Continued from page 20A)

Alcoa to Build New Alumina Plant. The Aluminum Company of America (Alcoa) has announced plans for construction of a new alumina plant near Bauxite, Ark., designed to process low-grade ore. To be operated by the Aluminum Ore Company, wholly owned subsidiary of Alcoa, the new plant will be situated on a 200-acre site adjoining the bauxite mining operations of the Alcoa Mining Company, also a wholly owned subsidiary of Alcoa. The entire construction project will be carried out by the parent company, serving as its own contractor.

Federal Telephone and Radio Appoints Sinclair. A. E. Sinclair has been named Industrial Relations Director of the Federal Telephone and Radio Corporation, Clifton, N. J., an associate company of the International Telephone and Telegraph Corporation.

Philco Appointment. O. O. Schreiber assistant secretary of the Philco Corporation, has also been appointed assistant to the President, William Balderston.

G-E to Build New Electronics Plant; Forms New Chemistry Divisions; Appointments. The Electronics Department of the General Electric Company has announced plans for construction of a million dollar electronics plant at Auburn, N. Y. General Electric has also announced formation of new Chemistry Divisions of the General Electric Research Laboratory, with Dr. A. L. Marshall as manager and Anthony J. Nerad as assistant manager. The new group consists of five divisions—Organic, Physical, Analytical, Chemistry, Chemical Process Engineering—and the Mechanical Investigations Division. Dr. William E. Cass has been named head of the Organic Chemistry Division, with Dr. John R. Elliott as associate head; Dr. Herman A. Liebhafsky heads both the Analytical and Physical Chemistry Divisions; Dr. Albert E. Schubert is in charge of the Chemical Process Engineering Division; and Mr. Nerad will continue to supervise the Mechanical Investigations Divisions, in addition to his duties as assistant manager of the divisions.

The company has also announced the following appointments: Emil R. Schaeffer, manager of manufacturing, Switchgear Divisions, Philadelphia, Pa.; Henry A. Vaughn, manager of manufacturing, Meter and Instrument Divisions, Lynn, Mass.; Ab Martin, manager of the Fort Wayne, Ind. works, Apparatus Department; C. H. Matson, manufacturing consultant, Small Apparatus Divisions Staff; Dr. Ferd E. Williams, head, Light Production Division, General Research Laboratory, and Dr. Leroy W. Apker, head, Semi-Conductors Division, General Electric Research Laboratory.

H. K. Porter Company Acquires Delta Star Electric Company. The H. K. Porter Company, Inc., Pittsburgh, Pa., has acquired the Delta Star Electric Company

(Continued on page 35A)

(*Continued from page 26A*)

f Chicago, Ill., manufacturers of high-oltage electric equipment. Following a olicy of diversification of its manufactur-ng operations, Porter has expanded its perations into rubber, steel, and electric quipment by the acquisition of the Quaker ubber Corporation, the Conners Steel ompany, and now the Delta firm. The ompany already operates the Hinder-ter Tool Company Division, Tulsa, Okla., the American-Fort Pitt Spring Division, and the Jarecki Manufacturing Company.

urndy Engineering Appoints Harris. he Burndy Engineering Company, Inc., anufacturer of electric connectors, has ppointed David H. Harris as assistant dvertising and sales promotion manager.

nited States Steel News. The United tates Steel Company and its subsidiary ompanies have announced the following ppointments: Albert J. Berdis, general uperintendent of the company's Fairless Vorks; Clinton H. Currier, assistant anager of the Electrical Products Sales Division of the American Steel and Wire Company; Clyde B. Colwell, Jr., assistant istrict manager, Twin Cities district, nited States Supply Company; and L. . Johnson, chief engineer, National Tube Company. United States Steel has also nnounced the retirement of John G. Munson, Vice-President, United States Steel Corporation of Delaware. Mr. Munson's position has not been filled yet.

Lovell Elected a Director of Raytheon. Stanley P. Lovell, 1948 recipient of the Presidential Medal for Merit, has been elected a director of Raytheon Manufacturing Company, Waltham, Mass.

Sylvania Appointments. Roy E. Drew has been made controller for the Television Picture Tube Division, and H. Allen White has been appointed sales service engineer for the Radio Tube Division of Sylvania Electric Products, Inc.

Bendix Acquires Two New Plants. The Bendix Aviation Corporation has purchased the property and facilities of the Victor Animatograph Corporation at Davenport, Iowa, and also the Ford Motor Company plant at Hamilton, Ohio. Both plants were purchased in order to expand the production of aircraft parts and accessories for the armed services.

Allis-Chalmers Appointments. The Allis-Chalmers Manufacturing Company has announced the following appointments: G. F. Friauf has been appointed general material supervisor; John F. Costigan has been named assistant works manager of the company's Norwood (Ohio) works; and Thomas C. Smith, Milwaukee, E. E. Strickland, Jr., New York, and Elwood C. Gerber, Pittsburgh, have all been appointed sales representatives to Allis-Chalmers general machinery division district offices.

Rockbestos Appoints Chemical Engineer. Lester E. Robb has been made chemical engineer of the Rockbestos Products Corporation, New Haven, Conn.

Radio-Television Industry's 1950 Sales Break All Past Records. The Radio-Television Manufacturers Association has reported that close to 7,500,000 television sets and over 14,000,000 radios were manufactured during 1950, with manufacturer's sales amounting to about $1,700,000,000, which represents an increase of 90 per cent over 1949 sales and 125 per cent over 1948's record.

Weston Appointments. Arthur L. Morrison has been named purchasing agent and Thomas H. Closs has been made northeastern and eastern Maryland representative of the Weston Electrical Instrument Corporation, Newark, N. J.

Lenkurt Names Director of Engineering. Kurt Appert, Vice-President and chief engineer of the Lenkurt Electric Company, has been made Director of engineering

(*Continued on page 36A*)

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Your electrical precipitator installation will be individually engineered...and based on the Research Corporation's *experience* graphically shown by that towering pile of thousands of blue prints.

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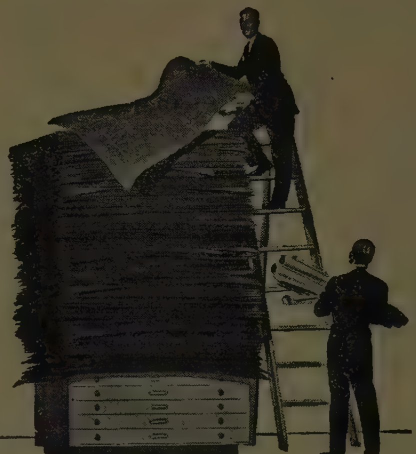
Research Corporation Cottrells can be made as efficient as you desire. They can collect 95% to over 99% of all solid or liquid particles suspended in gas entering equipment. Write for free booklet giving valuable data. RC-121



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More ILSCO CONNECTORS are used in safety switch breakers, panel boards and many other electrical installations than all others combined.

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ILSCO COPPER TUBE & PRODUCTS, INC.

(*Continued from page 35A*)

there. George M. Lebedeff succeeds Mr. Appert in his former post as chief engineer.

RCA Victor News. Edwin Dorsey Foster, Vice-Admiral, United States Navy, retired, has been appointed Director of a newly established Mobilization Planning Department of the RCA Victor Division of the Radio Corporation of America. This new department is designed to assure the most effective operation to meet government requirements for research, development, and manufacture of vital electronics equipment for the nation's defense program. RCA Victor also has announced the appointment of Julius Haber as Director of advertising and sales promotion for RCA technical products.

Stewart-Warner Moves Plant. Stewart-Warner Electric, the radio and television division of Stewart-Warner Corporation, has acquired a new plant at 1300 North Kostner Avenue, Chicago, Ill., to which manufacturing operations now located at the corporation's main plant on Diversey Parkway will be moved.

Wellman Engineering Purchases Anker-Holth. The Wellman Engineering Company of Cleveland, Ohio, has purchased the property and business of the Anker Holth Manufacturing Company of Port Huron, Mich.

NEW PRODUCTS • •

Electromagnet. The *ADL* Electromagnet, a new research unit for producing high flux-density magnetic fields, was developed by Arthur D. Little, Inc., in co-operation with Professor Francis Bitter of the Massachusetts Institute of Technology. This magnet, weighing about two tons, produces the same magnetic fields as other electromagnets weighing 15 to 50 times as much. The unit contains built-in automatic controls and safety devices, minimum stray electromagnetic interference, easily interchanged pole pieces, accurate, easily installed spacers, a detached cooling unit and a wide power range which permits use of standard generating arrangements Field strength is from 10,000 gausses to 35,000 gausses, with power ratings from 20 kw to 125 kw. For further information contact Arthur D. Little, Inc., Mechanica Division, 30 Memorial Drive, Cambridge 42, Mass.

Beta-Gamma Hand and Foot Checker The Austin Company, Special Device Division, 19 Rector Street, New York 6 N. Y., has introduced a radiation detectio device for protection of personnel in industrial plants, laboratories, and other area where radioactive materials are stored o used. The model was engineered an manufactured under contract with th Atomic Energy Commission. The em ployee steps on the foot checker platfor

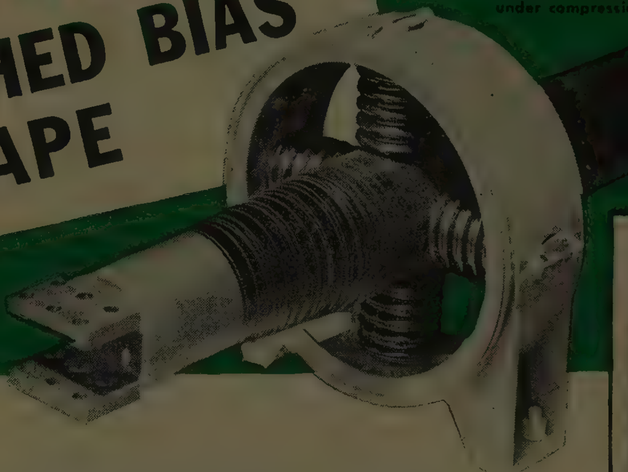
(*Continued on page 38A*)

R&IE

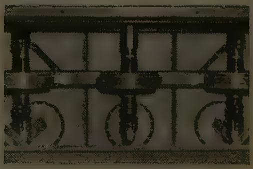
ISOLATED PHASE HEAVY DUTY BUSES FOR Consolidated Edison ARE INSULATED WITH NATVAR VARNISHED BIAS TAPE

A completed portion of metal enclosed bus and switches shows how neat and compact the 3500 Ampere Isolated Phase Bus installation is at Consolidated Edison's Waterside No. 1 station.

Insulator ring support section and 3500 Ampere conductor taped with Natvar V C tape as in the Isolated Phase Bus installation in Consolidated Edison's Waterside No. 2 station. Insulators are always under compression.



Progressive views of procedure in taping a 2000 Ampere conductor for switch terminal and expansion joint in Consolidated Edison's Jamaica station:



Partly taped section of conductor held by insulator ring support.

Taping shield installed over flexible connection, ready for final taping.

Taping completed. Bus is now ready for metal enclosure.

Metal Enclosed Isolated Phase Bus structures built for Consolidated Edison Co. by Railway and Industrial Engineering Co., Greensburg, Pa., for high voltage, high capacity, call for high reliability in service, a minimum of maintenance and a compact yet flexible arrangement. Each system is designed for its specific installation, and completely fabricated at the factory for final assembly on the job.

Component parts and materials must be of top quality. Conductors are taped with Natvar varnished bias tape because of its uniformly good electrical and physical properties.

Natvar flexible insulation is available either from your wholesaler's stocks or direct from our own.

Natvar

Natvar Products
- Varnished cambric—straight cut and bias
- Varnished cable tape
- Varnished canvas
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- Varnished silk
- Varnished special rayon
- Varnished Fiberglas cloth
- Silicone coated Fiberglas
- Varnished papers
- Slot insulation
- Varnished tubings and sleevings
- Varnished identification markers
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- Extruded vinyl tubing and tape
- Extruded vinyl identification markers

Ask for Catalog No. 21

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Your Electrical System is as DEPENDABLE as the QUALITY of its CONNECTORS . . .

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THE CRITERION OF ANDERSON BRASS PRODUCTS

PRODUCT QUALITY RESULTS FROM------

★ ENGINEERING . . . designs based on many years of coordinated electrical mechanical and metallurgical engineering knowledge and experience gained in meeting and maintaining the most exacting standards of the electrical industry.

★ MANUFACTURING . facilities including complete foundry, machine shop and assembly operations in one plant under the supervision of competent personnel. Quality control, physical, mechanical and electrical tests are conducted during production by our engineers and inspectors to insure a high standard of quality of manufactured parts.

★ MATERIALS . . . used are of the highest grade alloys and virgin metals obtained in accord with our rigid specifications. Hardware components are the finest available and are required to conform with our exacting standards.

OUR PRODUCTS ARE QUALITY CONTROLLED FROM INGOT TO FINISHED PRODUCT

Write Today for Bulletin K-175 on "K" and "KR" Distribution Connectors.

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• BRONZE AND ALUMINUM POWER CONNECTORS, FITTINGS, AND BUS SUPPORTS
ALUMINUM SUSPENSION AND STRAIN CLAMPS

(Continued from page 36A)

placing his hands in the hand checker pockets. Automatic switches put the system into operation, and Gieger-Mueller tubes transmit pulses through electronic scalers to electromechanical registers (counters) proportional to the number of beta-gamma rays striking each tube. In a few seconds the five registers provide a beta-gamma count of the palm and back of each hand, as well as the feet of the employee. If the count on any one of the registers is higher than permissible, the employee reports for decontamination. Stepping off the device automatically resets the registers for the next employee. Additional details may be obtained from the Austin Company upon request.

Oscillograph-Record Camera. A new oscillograph-record camera, announced by the Instrument Division of Allen B. Du Mont Laboratories, provides a complete record of an oscillograph image in one minute. No darkroom facilities are required; wave form comparison is immediate. The camera has been designed specifically for application with any standard 5-inch cathode-ray oscillograph. The camera employs the polaroid-land process for delivering a finished print at the termination of each completed exposure or set of exposures. By means of a sliding mount, the camera may be positioned so that several traces can be recorded on a single print, for side-by-side comparisons. There is also a built-in detent which divides a single print into one, two, or three separate exposure areas. This feature facilitates economical use of the film. Print size is $2^1/_4$ by $3^1/_4$ inches, with a ratio of dimensions from trace to recording of 2.25:1. Further information on this new polaroid oscillograph-record camera may be obtained from Allen B. Du Mont Laboratories, Inc., Cathode-Ray Instrument and Tube Divisions, 1000 Main Avenue, Clifton, N. J.

Spot-Welding Control. The Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa., has introduced new synchronous and nonsynchronous control equipment for low-capacity spot-type resistance welding machines. Air-cooled thyratron tubes with no moving parts make and break the welding current. All components in each equipment are mounted on a side-swinging panel enclosed for ease of inspection and maintenance. The units can be mounted on or near the welding machine. Knockouts are provided in the enclosure t facilitate making external electric connections. Synchronous units can be supplied in rms current ratings up to 50 amperes a 10-per cent duty cycle. Nonsynchronou units are available in ratings up to 10 amperes at 10-per cent duty cycle. Fo further information, contact the Westinghouse Electric Corporation.

Vacuum Furnace. The National Research Corporation has introduced a typ 29-0410-18 vacuum furnace which operate

(Continued on page 48A)

BIDDLE *Instrument News*

- ELECTRICAL TESTING INSTRUMENTS
- SPEED MEASURING INSTRUMENTS
- LABORATORY & SCIENTIFIC EQUIPMENT

NUMBER 5 OF A SERIES

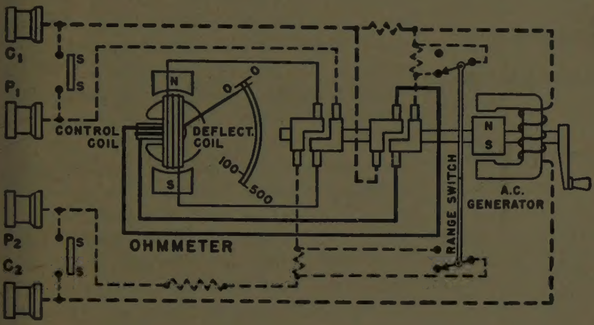
JAMES G. BIDDLE CO., 1316 ARCH ST., PHILADELPHIA 7, PA.

NEW CVM TYPE MEGGER® GROUND TESTER

...Provides Simple, Single Test Method for Measuring Resistance of Earth to Ground Connections

This modern design, strong, compact ground tester weighs only 6 pounds, measures 7½″ x 5″ x 5¾″. An ideal, easy-to-use field instrument for determining if the resistance to earth of man-made grounds is sufficiently low to minimize dangers due to lightning.

It is a completely self-contained test set with its own generator for supplying test current—no dependence on batteries or other current supply.



For complete details and prices on this *New* instrument, write for Bulletin 25-80-EE.

ELECTRICAL MAINTENANCE APPLICATIONS of LOW RESISTANCE MEASUREMENTS

Cable and Conductor Joints
Oil Circuit Breaker Assemblies
Rotating Equipment
Transformers and Coils

...QUICKLY CHECKED with DUCTER®
LOW RESISTANCE OHMMETER

High-resistance **conductor joints** and connections cause objectionable voltage drops, loss of power, and damage from localized heating. Quick and reliable measurements of joint and contact resistance during manufacture, at installation, and periodically while in service are therefore good insurance against malfunctioning and trouble.

Several of the joints and contacts throughout **oil circuit breakers,** from top-terminal of the bushings to associated bushings, may give serious trouble when unnecessary heating develops.

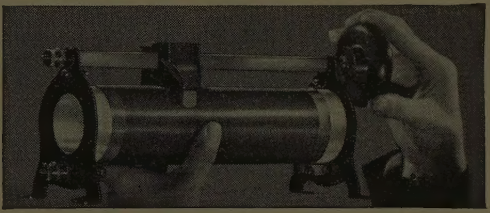
In **rotating equipment** shorted commutator bars, shorts in armature coils, and shorts between equalizers or cross connections, and also high resistance joints between commutator bars and risers, spell inefficient performance and trouble.

Proper winding resistances of **transformers and of coils** are as important as in any other electric circuit, with one exception — such windings have inductive characteristics, as well as d-c resistance.

Anyone familiar with these types of equipment can measure ohmic resistances down to a few millionths of an ohm with the DUCTER® Low Resistance Ohmmeter. Valuable information on this subject is contained in our Bulletin 24-25-EE.

"JAGABI"® LUBRI-TACT POWER RHEOSTATS

Standard Types in 76 Different Ratings



For fine adjustment and control of electrical current—from "zero" to as high as 25 and 50 amperes. Engineers and laboratory workers find "Jagabi" Rheostats have many superior refinements, including the Lubri-tact, graphited carbon lubricator brush which slides with a phosphor bronze current-carrying brush—no scratching or sticking on the resistance winding even at high temperatures. Solid wall porcelain tubes assembled by expert workmanship, with precise adjustment and control, combine to make "Jagabi" a sturdy long lasting construction.

Among the many varieties manufactured by James G. Biddle Co. craftsmen are screw drive rheostats, double rheostats with one or two sliders, water cooled rheostats, graded rheostats up to 24″ long with different sizes of resistance wire, switchboard rheostats, rheostats in metal cages, and non-inductive rheostats.

Bulletin 41-EE is a thorough description of "Jagabi" Lubri-tact, as well as "Jagabi" Compression Carbon Rheostats for controlling heavy current . . . also "Jagabi" Resistance Units. Your request will bring this booklet by return mail.

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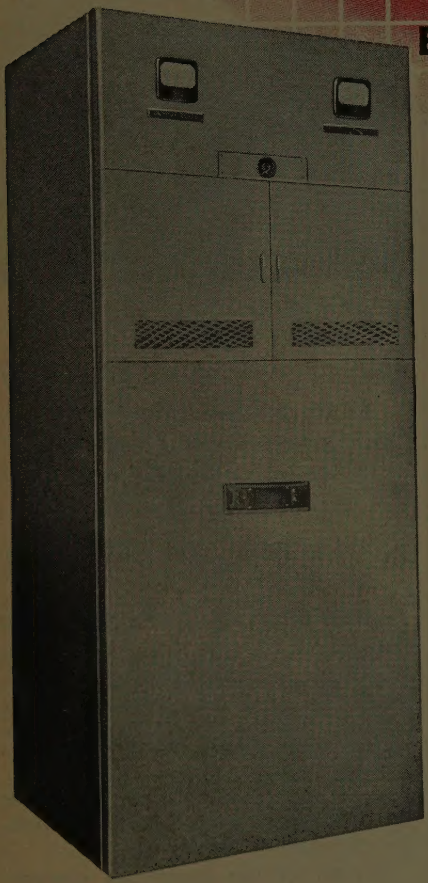

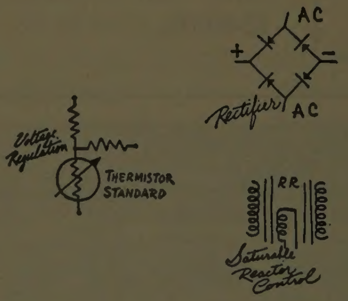

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PECo Battery Chargers establish a new standard of efficiency in charging equipment . . . Incorporating the latest developments in selenium rectifier stacks, transformers and saturable reactors, power loss has been cut to a minimum. Convection cooled, there are no fans, blowers or other moving parts; thus maintenance is minimized, and stand-by power loss reduced to practically zero. Important, too, is the fact that this new higher efficiency has been achieved with *no sacrifice* of control accuracy . . . Look into a PECo Battery Charger; you will find an outstanding quality in both workmanship and material; you will find that every component is conservatively rated to give an extra guarantee of safety, efficiency and durability . . . Write today for complete information.

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Specialists in Controlled Rectifiers Since 1935

55 ANTOINETTE STREET DETROIT 2, MICHIGAN

(*Continued from page 38A*)

at high temperature and high vacuum or controlled atmosphere. Heat treating, sintering, annealing, melting, and pouring can all be performed in this one unit. In the heating element assembly, which is contained in a water-cooled stainless-steel sleeve, a single-turn tungsten sleeve is surrounded by molybdenum and nickel heat shields. Heat shields are fixed in place at the bottom. This element has the following advantages: high temperature—up to 2,000 degrees centigrade; close control of temperature; even heat throughout the hot zone; and no refractories to outgas, which improves vacuum conditions and minimizes the hazard of contaminating critical melts. Power is taken directly from the mains through a pair of special autotransformers, which serve the dual purpose of dropping the line voltage and providing control of power input to the furnace. Maximum voltage across the standard element is 15 volts. For protection, the power supply is interlocked with a pressure switch in the cooling water line. The vacuum system is built around the new purifying-type oil diffusion pump. This pump blanks off at about 4×10^{-7} millimeter of mercury absolute when charged with Narcoil 20 diffusion pump fluid. It also has a relatively high speed in the pressure region of 1×10^{-3} to 1×10^{-2} millimeter which is particularly helpful to pump away outgassing and generally assist the mechanical pump in the region of its blank-off pressure. The diffusion pump is backed by a 12.5-cubic-foot-per-minute Kinney mechanical pump. This combination provides a speed of better than 320 liters per second at 1×10^{-4} millimeter and 300 liters per second at 1×10^{-3} millimeter or 1 micron. The entire system, including the hot outgassed furnace, blanks off at less than 5×10^{-5} millimeters. Further information may be obtained from National Research Corporation, 70 Memorial Drive, Cambridge 42, Mass.

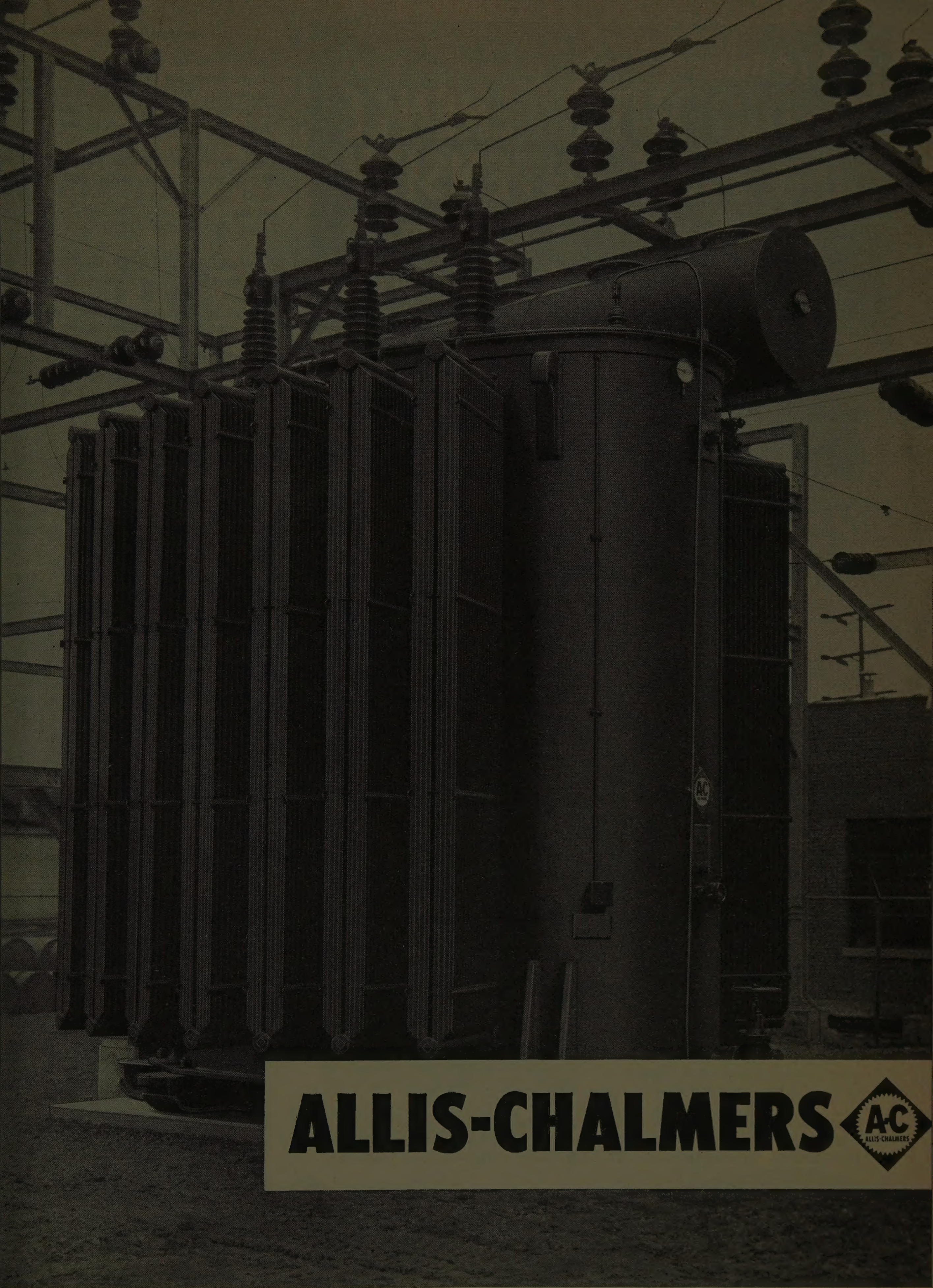
TRADE LITERATURE

Resonant Reed Tachometers. The James G. Biddle Company, 1316 Arch Street, Philadelphia 7, Pa., has released a new bulletin, number *31*, which contains information on Frahm resonant reed tachometers for measuring speed and rate of vibration. These instruments operate without direct contact with moving parts under test, and require no electrical connections, belts, gears, or couplings. The bulletin may be obtained upon request.

Bending Information. The O'Neil-Irwin Manufacturing Company, Lake City, Minn., has issued a 32-page manual on the cold bending of metals. It is available from the company.

Paraplex Booklet. Complete data on uses of the Paraplex "P" series resins (solutions of polyester resins in styrene), in the laminating, molding, potting, and

(*Continued on page 52A*)



5 **MORE POWER TO SOUTHWEST!** Not alone relief from heavy power demands today, but faithful power for ears to come. The specifications: "20,000 kva, 3-phase, 60-cycle. 55°C rise, *Oil-Sealed* inert gas system, 66,000 volts Y to 13,800 volts Delta" . . . as fine a power transformer as years of engineering background can produce! *Oil-Sealed* is an Allis-Chalmers trademark.

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Frequency range includes Citizens Band and UHF color TV Band.

These instruments comply with test equipment requirements of such radio interference specifications as JAN-I-225, ASA C63.2, 16E4(SHIPS), AN-I-24a, AN-I-42, AN-I-27a, AN-I-40 and others.

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(*Continued from page 48A*)

casting fields are contained in a new booklet published by the Resinous Products Division of Rohm and Haas Company, Washington Square, Philadelphia 5, Pa. Copies are available upon request.

Lefax Technical Books Catalog. Over 2,000 listings of Lefax pocket-size technical books are contained in their new 1951 catalog. It is available by writing to Lefax, Philadelphia 7, Pa.

Standardized Steam Turbine Units. A new booklet, number nine in a series designed to keep the engineer in touch with current trends in power plant development, "Standardized Steam Turbine Units," *03B6801A*, has been published by the Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis. The booklet covers the six sizes of standardized units—11,500, 15,000, 20,000, 30,000, 40,000, and 60,000 kw—and the recommended 90,000-kw turbine. It may be obtained upon request to the company.

Precision Instruments. Dawes Instruments, Limited, 130 Uxbridge Road, Hanwell, London W 7, England, has published a bound catalog containing full details of their precision electronic instruments for scientific, industrial, and photographic applications. The catalog is available upon request to the company.

Service Restorer and Switch Data. The Pacific Electric Manufacturing Corporation has issued three new catalogs: Catalog *840* describes their type AP-40 3-pole automatic service restorer (14.4 kv motor-rewound reclosing type); Catalog *121* contains information on their type TW-1 outdoor group-operated rotating-insulator vertical break air switch; and catalog *120* describes their type TW-0 outdoor group-operated rotating-insulator vertical break air switch. All three catalogs are available upon request to the company, at 5815 Third Street, San Francisco 24, Calif.

Conveyor and Elevator Belts. The B. F. Goodrich Company, Akron, Ohio, has issued a catalog, number *2200*, which describes construction and the functions of its line of conveyor and elevator belts. Copies may be obtained upon request.

Switchgear. Allis-Chalmers indoor and outdoor switchgear for protection and flexible control of power and distribution circuits has been described in a new bulletin, "Allis-Chalmers Switchgear," *18B6185A*, which is available upon request from the Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

X-Ray Photometer. A new bulletin on the X-ray photometer for chemical analyses by X-ray absorption has been announced as available from the General Electric Company, Schenectady 5, N. Y. Designated publication *GEC-412A*, it lists some of the applications for the instrument in the petroleum and chemical industries.